DEPARTMENT OF THE ARMY
TECHNICAL MANUAL

DEPARTMENT OF THE AIR
FORCE TECHNICAL ORDER

TM 11-2057A
TO 16-35TS27-6

COPY NO. 2

TEST SET
TS-27B/TSM

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DEPARTMENTS OF THE ARMY AND THE AIR FORCE

OCTOBER 1952

TM 11-2057A/TO 16-35TS27-6

TEST SET
TS-27B/TSM

United States Government Printing Office
Washington : 1952

DEPARTMENTS OF THE ARMY
AND THE AIR FORCE
WASHINGTON 25, D. C., *9 October 1952*

TM 11-2057A/TO 16-35TS27-6 is published for the information and guidance of all concerned.

[AG 413.6 (17 Sep 52)]

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NG: Same as Active Army except one copy to each unit.

ORC: Same as Active Army except one copy to each unit.

For explanation of distribution formula, see SR 310-90-1.

TECHNICAL MANUAL

TEST SET TS–27B/TSM

TM 11–2057A
CHANGES No. 2

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *2 December 1955*

TM 11–2057A, 9 October 1952, is changed as follows:

The following information changes TM 11–2057A so that the manual applies also to the following equipment:

Nomenclature	*Order No.*
Test Set TS–27B/TSM	16190–Phila–55

Page 1, chapter 1, add the following note at the beginning of chapter 1.

Note. Test Set TS–27B/TSM procured on Order No. 16190–Phila–55 is similar to Test Set TS–27B/TSM covered in the manual, including Changes No. 1, except for certain minor mechanical differences which are covered in this change. Information in the technical manual, including Changes No. 1, applies to the TS–27B/TSM (16190–Phila–55) unless otherwise specified in this change.

Page 4, paragraph 5, make the following changes:

In *c* (C1), in the table, change "1 Capacitance-Resistance Bridge ZM–7A/TSM" to read: **1 Capacitance-Resistance Bridge ZM–7A/TSM or ZM–7B/TSM.**

In *c*, at the end of the table, add the following:

1 Battery spacer (fill-in for Batteries BA–63).
1 Battery tray (holder for Batteries BA–30).

Add the following note after the table:

Note. Batteries listed above must be requisitioned through regular supply channels when needed.

Page 5, paragraph 6, in *c*, after the eighth sentence, add the following: A wooden battery spacer is provided to accommodate smaller 45-volt batteries such as Battery BA–63.

Page 30, paragraph 25, make the following changes in *b:* In the table, delete "Solvent, dry-cleaning (SD) QM 51–S–4381–1 (Quartermaster stock number)" and substitute the following: **Cleaning Compound (Federal stock No. 7930–395–9542).**

Add the following to the existing note: Prolonged breathing of Cleaning Compound fumes is dangerous. Make certain that adequate ventilation is provided. Cleaning Compound is flammable; do not use near a flame.

d, in third and fourth sentences, delete "solvent (SD)" and substitute: **Cleaning Compound.**

Page 32, paragraph 26, in the following places, in the "How to Check" column, delete "solvent (SD)" and substitute: **Cleaning Compound.**

Item 1. Line 7.

Item 2. Line 13.

Item 3. Line 7.

Page 35, paragraph 31, make the following changes:

In the first sentence, delete "is provided with" and substitute: **uses.**

In the fifth sentence, delete the word "new."

Page 37, paragraph 34, in the introductory sentence, change "Test Set TS–27/TSM" to read: **Test Set TS–27B/TSM.**

Page 44, figure 19 (C 1), on figure 19, substitute "**2W**" for "4W" (wattage of variable resistor R12).

Page 48, paragraph 36,

36. Test Equipment Required for Troubleshooting

(Superseded)

The equipment listed below is required for troubleshooting.

Test equipment	Use
Electron Tube Test Set TV–7/U	For testing tubes.
Multimeter TS–352/U	For general use in checking continuity of circuits.
Test Set ZM–4/U	Precision measuring of resistors used in the TS–27B/TSM.

Page 53, figure 20 (C 1), make the following changes on figure 20:

Substitute "**2W**" for "4W" (wattage of variable resistor R12)

Substitute "**1W**" for "2W" (wattage of resistor R18).

Page 54, paragraph 40, make the following changes:

In table II, delete the line above the last (all information pertaining to T1).

In table III, in the third line above the chart, change "92" to read: **90.**

In table III, delete the existing tabular matter and substitute the following:

Item	Terminal	Voltage
XV1	1	0
	2	86
	3	56
	4	0
	5	1. 5
	6	−0. 4
	7	*NC
	8	1. 5
XV2	1	*NC
	2	1. 5
	3	87. 5
	4	90
	5	−4. 4
	6	*NC
	7	1. 5
	8	0
T1	1	88. 5
	2	90
	3	89. 5
	4	90
	5	90

*NC—No connection.

Page 59, paragraph 44, in *b,* first sentence, change "Tube Tester I–177–A" to read: **Electron Tube Test Set TV–7/U.**

Page 61, paragraph 45, add the following to the "caution" following *b:* On the TS–27B/TSM (16190–Phila–55), a metal guard ring protects the slide wire. The ring does not affect slide wire disassembly.

Page 62, figure 26, add the following note:

NOTE. ON TEST SET TS–27B/TSM (16190–PHILA–55) THE POSITIONS OF RESISTOR R1 AND CONNECTOR J1 ARE TRANSPOSED.

Page 63, figure 27, add the following note:

NOTE. ON TEST SET TS–27B/TSM (16190–PHILA–55) THE POSITIONS OF RESISTOR R1 AND CONNECTOR J1 ARE TRANSPOSED.

Page 65, paragraph 48, add the following to *e:* Oscillator frequency is 20 ± 3 cps.

Page 66, paragraph 50, in the second sentence, change "(S1)" to read: (**S6**).

Page 68, paragraph 52, in *b,* second sentence, change "solvent (SD)" to read: **Cleaning Compound.**

[AG 413.6 (28 Oct 55)]

By order of the Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

Official:

JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

CNGB (1)
Tec Svc, DA (1)
Tec Svc Bd (1)
CONARC (5)
CONARC Bd (Incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Tng Div (2)
Ft & Cp (2)
USMA (5)
Gen & Br Svc Sch (5) except SigC Sch (25)
Gen Depots (2) except Atlanta Gen Depot (None)
SigC Sec, Gen Depots (10)
SigC Depots (20)
POE (2)
OS Sup Agencies (2)
SigC Fld Maint Shops (3)
SigC Lab (5)
Mil Dist (1)
Units organized under following TOE's:
6–100R, Div Arty, Inf Div (2)
6–101R, Hq & Hq Btry, Div Arty, Inf Div (2)
6–200R, Div Arty, Abn Div (2)
6–201R, Hq & Hq Btry, Div Arty, Abn Div (2)
6–300R, Div Arty, Armd Div (2)
6–301R, Hq & Hq Btry, Div Arty, Armd Div (2)
6–401R, Hq & Hq Btry, FA Gp (2)
6–501R, Hq & Hq Btry, Corps Arty or Abn Corps Arty (2)
6–575R, FA Obsr Bn (2)
6–577R, FA Obsr Btry (2)
7R, Inf Div (2)
11–7R, Sig Co Inf Div (2)
11–15R, Sig Bn, Corps or Abn Corps (2)
11–16R, Hq & Hq Co, Sig Bn Corps or Abn Corps (2)
11–25R, Sig Cons Bn (2)
11–27R, Sig Cons Co (2)
11–57R, Armd Sig Co (2)
11–95R, Sig Opr Bn (2)
11–97R, Wire Opr Co (2)
11–127R, Sig Rep Co (2)
11–128R, Sig Depot Co (2)
11–500R (AA–AE), Sig Svc Org (2)
11–537R, Sig Co Amph Spt Brig (2)
11–557R, Abn Sig Co (2)
11–587R, Sig Base Maint Co (2)
11–592R, Hq & Hq Co, Sig Base Depot (2)
11–597R, Sig Base Depot Co (2)
17R, Armd Div (2)
20–300R, Amph Spt Brig (2)
32–500R, Comm Recon Org (2)
57R, Abn Div (2)

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1955

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Figure 1. Test Set TS-27B/TSM.

CHAPTER I

INTRODUCTION

Section I. GENERAL

1. Scope

a. These instructions are published for the information and guidance of the personnel to whom the equipment is issued. They contain information on the operation, organizational maintenance, and field maintenance of the equipment, as well as a discussion of the theory of operation. They apply only to Test Set TS-27B/TSM.

b. Appendix I contains a list of current references, including supply catalogs, technical manuals, and other available publications applicable to the equipment. Appendix II contains an identification table of parts.

2. Forms and Records

The following forms will be used for reporting unsatisfactory conditions of Army equipment and in performing preventive maintenance:

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army) and AFR 71-4 (Air Force).

b. DA AGO Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer, as prescribed in SR 700-45-5.

c. AF Form 54, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700-45-5 and AFR 65-26.

d. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. Purpose

Test Set TS-27B/TSM provides a means of testing wire communication lines and of locating faults in such lines. It may be used for direct measurements of conductor and insulation resistance and for the location of grounds, crosses, and shorts. It also may be used for the measurement of capacitance and for the location of opens in wire lines.

4. Tabulated Data

Measurements:

Resistance . . . . . 0 to 50 megohms.

Capacitance . . . . . .075 to 3.0 microfarads.

Accuracy:

Resistance measurements . . . . . ohms ±2.0%.
ohms x 100 ±5.0%.

Capacitance measurements . . . . . ±5.0%.

Power Supply:

External . . . . . none.

Internal . . . . . 1.5 v, 4.5 v, 90 v.

Oscillator frequency . . . . . 20 cps ±3 cps.

5. Packaging Data and Tables of Components

a. DOMESTIC. When packed for domestic shipment one Test Set TS-27B/TSM is placed in a moisture-vapor-proof container. Three of these containers are then placed in a wooden shipping container. A typical illustration for domestic shipment is shown in figure 2. The size, weight, and volume are shown in the table below.

Number of Units	Contents	Height (In.)	Width (In.)	Depth (In.)	Volume (Cu. ft.)	Unit Weight (Lb.)
3	Test Set TS-27B/TSM	16-1/2	17-3/4	36	6.11	147

b. EXPORT. Packaging of the Test Set TS-27B/TSM for export shipping is the same as for domestic shipping.

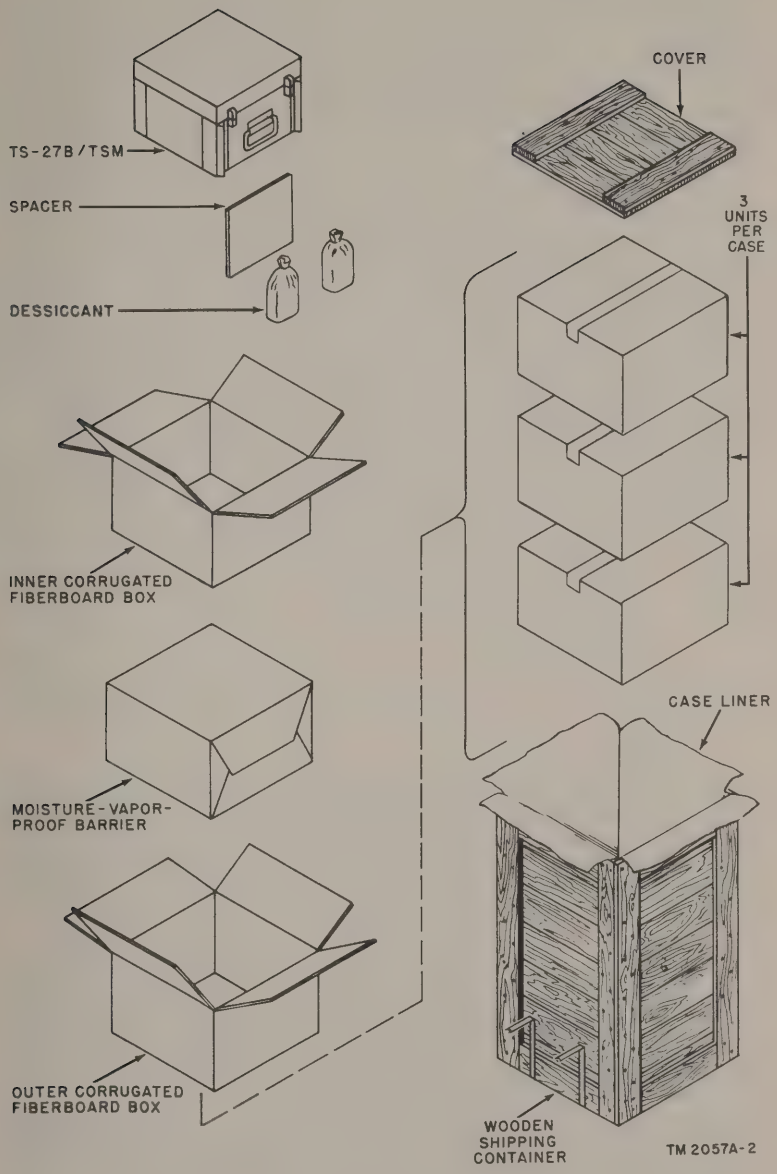

Figure 2. Test Set TS-27B/TSM, Packaging Data.

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c. TABLE OF COMPONENTS.

Quantity	Component	Dimensions (Inches)			Weight (Lbs)
		Height	Width	Length	
1	Test Set TS-27B/TSM Consisting of:	9	13	13-1/2	23
	1 Case	9	13	13-1/2	
	1 Capacitance-Resistance Bridge				
	1 Control panel				
	5 Test leads				10 oz
	2 Batteries 45-v, BA-59 or 2 Batteries 45-v, BA-63				
	1 Battery 4-1/2 v, BA-31				
	2 Batteries 1-1/2 v, BA-30 or 1 Battery 1-1/2 v, BA-15-A				
	1 Patch cord				4 oz

6. Description

a. Test Set TS-27B/TSM (fig. 1) comprises a single self-contained unit which is supplied complete with five leads for making rapid connections to wire communication lines and a cord for use when it is more convenient to plug into a switchboard than to connect directly to the line being tested. Two spare vacuum tubes also are furnished with the unit.

b. The unit is contained in a portable watertight carrying case 13-1/2 inches long, 13 inches wide, and 9 inches high. The unit, complete with all accessories, weighs approximately 30 pounds. A circuit diagram is fastened to the inside of the case, below the test set. All wiring within the test set is color-coded or marked to aid in tracing circuits and in locating failures. All components are marked by the same circuit symbol used in the circuit diagram to facilitate replacement if necessary. Tabulated data to aid in the rapid location of line troubles are contained on the inside of the case lid in a chart assembly. The data also includes charts for converting dial scale divisions to microfarads. A chart of condensed instructions is pasted to the lid just under the chart assembly, and is also shown as fig. 30 at the end of this manual.

c. Test Set TS-27B/TSM is a form of Wheatstone bridge powered by dc (direct current) obtained from dry-cell batteries. It is used for measuring conductor and insulation resistance and for locating grounds, crosses, and shorts. When the test set is used for measuring capacitance and to locate opens, 20-cycle ac (alternating current) is supplied by a vacuum-tube oscillator. Two 45 volt Batteries BA-59 or BA-63 in series are used to energize the bridge when making d-c measurements. The vacuum tubes, which are used only for a-c measurements, receive plate power from the same two batteries mentioned above that are used for d-c measurements. Filament power is supplied either by a single 1-1/2-volt Battery BA-15-A or by two 1-1/2-volt flash-light type Batteries BA-30 connected in parallel. Grid bias is supplied by a 4-1/2-volt Battery BA-31. An adapter is provided for Batteries BA-30 so that they can be substituted readily for Battery BA-15-A. Two pairs of binding posts, T and R of PR-1 and T and R of PR-2, provide a means of connecting two pairs of wires to the test set simultaneously. Binding posts TEL are provided for connecting a telephone into the line circuits under test. A ground binding post is provided also. Two cam lever switches permit switching either pair of line test binding posts to the test circuit or to the telephone. These two switches are designated PR-1 TEST--TALK and PR-2 TEST--TALK. Four push switches are used. Three of these switches (OHMS, OHMS X100, and MEGOHMS) are used in connection with d-c measurements. The fourth switch, designated OPENS, is used only for a-c measurements. A view of the test set with the cover raised is shown in figure 1.

SAFETY NOTICE

There is no danger of harmful shock from Test Set TS-27B/TSM because the set is energized entirely by batteries, but one of the lines to be tested may form a cross with a high-tension power line. This may be dangerous to life as well as to the test set. Be careful. Handle lines suspected of carrying high voltage cautiously and only when hands are covered with material having a high insulating quality. Test the lines for indication of voltage before connecting them to the test set. Do this by touching the bare end of one line of a pair against the end of the other, and the ends of each separately to a ground. Note whether there is an arc or spark. Clear all binding posts when disassembling any part of this equipment.

CHAPTER 2

OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF MATERIEL

7. Uncrating and Unpacking

When uncrating and unpacking the equipment, avoid thrusting tools into the interior of the shipping container. Be careful not to damage packaging materials and containers any more than is necessary; these items may be required for future repacking. Carefully stow the interior packaging materials and containers within the wooden shipping container. When uncrating and unpacking, proceed as follows:

a. Unpack the equipment in a location where it will not be exposed to dust, dirt, or excessive moisture.

b. Cut the metal straps with a suitable cutting tool.

c. Remove nails from the top of the shipping container (fig. 2) with a nail puller.

d. Carefully cut the tape and seals of the case liner, so that the waterproof paper will be damaged as little as possible.

e. Lift out the packaged equipment.

f. Carefully cut the tape, which seals the flaps of the carton, so that the carton will not be damaged.

g. Cut the barriers and carefully remove the inner carton.

h. Open the inner box and remove the cushioning material and the desiccant.

i. Lift out the equipment.

j. Return all interior cushioning materials to the inner carton for re-use in future repacking of the equipment.

8. Checking

a. Inspect the outside of the carrying case for signs of mechanical damage, such as dents, broken handle, or broken latches.

b. Release the catches and remove the cover from the case.

c. Thoroughly check the equipment against the packing list to see if any part is missing.

d. Thoroughly inspect the equipment for signs of possible damage during shipment.

Note. When used equipment is received, follow the same procedure as outlined in paragraphs 7 and 8 for new equipment.

Section II. CONTROLS AND INSTRUMENTS

9. Controls

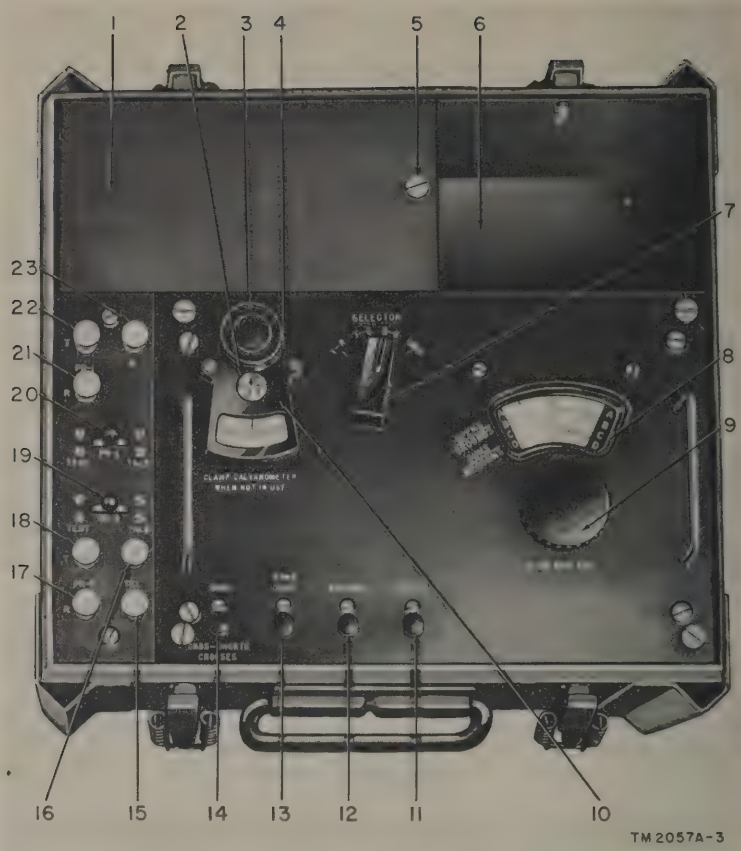
a. GENERAL. All controls used in operating Test Set TS-27B/TSM are located on the main panel (fig. 3) of the equipment. The controls are accessible after the top cover of the equipment is removed.

b. GALVANOMETER. The galvanometer is used to indicate the setting of the variable resistor R22 which will balance the capacitance-resistance bridge of the test set. The dial of the galvanometer (10, fig. 3) is graduated in 30 arbitrary divisions, 15 divisions on each side of zero. When the galvanometer pointer is opposite the zero in the center of the scale, the capacitance-resistance bridge is balanced.

c. GALVANOMETER CLAMP. When not in use, the galvanometer movement must be locked in position to prevent swinging of the needle and the coil. The galvanometer clamp button (2, fig. 3) locks the movement when the clamp is pushed toward the galvanometer knob. Move the clamp away from the knob to release the galvanometer movement.

d. GALVANOMETER ZERO-SETTING KNOB. The galvanometer knob (3, fig. 3) is used to set the needle to the zero mark on the scale when the needle is off zero with no current flowing through the meter coil. The knob is locked in position by means of a setscrew (4, fig. 3) in the side of the knob. To zero the galvanometer, place the test set on a level surface, loosen the setscrew in the side of the knob, and move the knob to center the needle on the zero marking. Tighten the setscrew.

e. POTENTIOMETER (R22). Variable resistor R22 is used to balance the resistance-capacitance bridge circuit. The setting of the slide-wire potentiometer R22 is adjusted by means of the large round knob (9, fig. 3) on the instrument panel. As the knob is moved, the SLIDE-WIRE DIAL located directly above the knob moves in the same direction.



1. Battery compartment cover.
2. Galvanometer clamp button.
3. Galvanometer zero-setting knob.
4. Galvanometer knob setscrew.
5. Battery compartment cover screw.
6. Test lead compartment.
7. SELECTOR switch (S7).
8. SLIDE-WIRE DIAL (R22).
9. SLIDE-WIRE DIAL (R22) knob.
10. Galvanometer dial.
11. OPENS push switch (S1).
12. MEGOHMS push switch (S4).
13. OHMS X100 push switch (S5).
14. OHMS push switch (S6).
15. TEL binding post (E1).
16. TEL binding post (E2).
17. PR-2 binding post R (E4).
18. PR-2 binding post T (E3).
19. PR-2 TEST - TALK lever switch (S3).
20. PR-1 TEST - TALK lever switch (S2).
21. PR-1 binding post R (E6).
22. PR-1 binding post T (E5).
23. Binding post G (for ground) (E7).

Figure 3. Test Set TS-27B/TSM, controls and instruments.

f. SLIDE-WIRE DIAL. The dial (8, fig. 3) located directly above the slide-wire knob indicates the position of the potentiometer. The dial has four scales A, B, C, and D. These letters are etched in the plastic window which protects the dial and the wire that forms the hairline.

(1) Scale A is divided into 20 divisions marked from 0 to 100 in equal steps of 5. When used with the proper conversion charts (fig. 4 through 12), this scale is used to measure capacitance and to locate open circuits in communication lines (par. 17e).

(2) Scale B is divided into 100 equal divisions. The two ends of the scale are marked 0, and the middle of the scale is marked 100. On each side of the 100 marking, the scale is marked in steps of 10 down to 0. This scale is used to locate shorts and crosses and is used as described in paragraph 17b.

(3) Scale C is divided and marked counterclockwise from 0 to 5000. When used in conjunction with OHMS push switch S6, the scale reads directly in ohms and indicates conductor resistance up to approximately 5,000 ohms. The scale readings also may be multiplied by 100, and resistance values from about 500 to 500,000 ohms may be measured by using the scale together with OHMS X100 push switch S5. On this higher scale the values obtained may be used to indicate low insulation resistance. Scale C also may be used to indicate the approximate location of shorts or crosses when the resistance per mile of the conductor being tested is known, and a good wire is not available.

(4) Scale D is divided in a manner similar to scale C, except that the divisions are marked from 0 to 50. This scale is used in conjunction with MEGOHMS push switch S4 and indicates resistance values in the range of 0 ohms to 50 megohms. This scale is the one generally used for insulation resistance measurements.

g. SWITCHES. Seven switches are mounted on the two panels of the test set. These switches are used to change connections to the external and internal circuits. The reference symbols, S1 to S7, mentioned in subparagraphs (1) through (7) below refer to figure 20.

(1) Push switch S1 (11, fig. 3) is marked OPENS and is located near the bottom of the instrument panel. This key-type push switch changes connections to the galvanometer and the filament circuit of the vacuum tubes. The galvanometer M1 is connected in parallel with the slide-wire potentiometer R22 (fig. 19). When OPENS push switch S1 is depressed, the test set is used to measure capacitance and to locate opens.

(2) Lever switch S2 (20, fig. 3) is located on the control panel and is marked PR-1. The switch is a lever-type switch which has two ON and one OFF positions. When the switch lever is moved to the side marked TALK, connections are made between the

line under test and a telephone set which can be connected to the terminal posts marked TEL. When the switch lever is moved to the side marked TEST, the line being tested is connected in the test circuit of the test set. Although the equipment is not marked off, the normal position of the lever switch is the off position.

(3) Lever switch S3 (19, fig. 3) is similar in all respects to lever switch S2, except that it is marked PR-2 and is used to make connections to a possible second pair of lines to be tested or to the pair used for talking.

(4) Push switch S4 (12, fig. 3) is located near the bottom of the instrument panel. This push switch is marked MEGOHMS and is used when measuring resistances having values above 500,000 ohms. When depressed, push switch S4 connects 1-megohm precision resistor R19 (fig. 20) as the standard and applies power to the bridge.

(5) Push switch S5 (13, fig. 3) is marked OHMS X100 and is similar to MEGOHM push switch S4. When depressed, push switch S5 connects precision 10,000-ohm resistor R20 (fig. 20) as the resistance standard for measuring resistances having values between 5,000 ohms and 500,000 ohms, and applies power to the bridge.

(6) Push switch S6 (14, fig. 3) is marked OHMS and is similar to push switch S4. When depressed, push switch S6 connects precision 100-ohm resistor R21 (fig. 20) as the resistance standard for measuring resistances having values below 5,000 ohms, and applies power to the bridge.

(7) SELECTOR switch S7 (7, fig. 3) is a two-wafer rotary selector switch that can be set into any one of four positions by turning the rectangular handle located near galvanometer M1. The switch is marked SELECTOR, and the four positions are marked T-R, T-G, R-G, and GNDS. The SELECTOR switch is used to connect the test set in any one of four of the five possible basic circuits provided by the equipment.

10. Panel Connections

Test Set TS-27B/TSM is provided with seven binding posts mounted on the control panel. The binding post in the upper right-hand corner of the control panel is marked G (23, fig. 3) and serves to connect an external ground to the test set. The two binding posts marked T and R of PR-1 (21 and 22, fig. 3) are used to make connections to a pair of lines being tested. Binding posts marked T and R PR-2 (17 and 18, fig. 3) are used to make connections to a second pair of lines when two pairs are to be tested at the same time, and, also, PR-1 is used for testing and PR-2 for talking. The two binding posts marked TEL (15 and 16, fig. 3) are used to connect a handset to the test set when it is desired to talk over a line being tested.

Section III. OPERATION UNDER USUAL CONDITIONS

CAUTION: To obtain correct readings, the operator should be thoroughly familiar with the theory of the equipment (pars. 34 and 35).

11. Preparation for Use

a. Release the latches and remove the cover.

b. Unclamp the galvanometer by sliding the clamp (2, fig. 3) forward, against the direction of the arrow.

Note. The reference symbols in parentheses in the legend of figure 3 are cross references of symbols marked on figures 19 and 26.

c. If necessary, adjust the galvanometer needle to zero by loosening the setscrew (4, fig. 3) and turning the galvanometer knob (3, fig. 3). Then tighten the setscrew.

d. If the equipment is to be used for trouble shooting on communication lines in the field, use the test leads provided (fig. 1) for making firm connections to the lines to be tested. Clips are provided at the ends of these leads. These clips have sharp pins which can cut through the line insulation and strong springs which insure a good electrical contact with the line. The other ends of the leads are provided with probes. Place the probes in the proper binding posts and fasten them firmly in place.

CAUTION: Do not use test picks or pointed test clips on Wire W-143. Make tests on Wire W-143 only at terminal strips, splices, or at loading coil connections.

e. When trouble-shooting on communication lines which terminate at a switchboard, it may be more convenient to use the patch cord (fig. 1) for making connections to the lines under test. The cord is terminated at one end in Plug Pl-51 and at the other end in three cord tips. Insert the plug into the switchboard jack to make connection with the line to be tested. Connect the tips at the other end to the appropriate test set binding posts.

12. Definitions of Line Trouble

Faults on a line may be of the following kinds:

a. One or both of the line conductors may be broken. This fault is called a break or an open. The nature of the break may be such that the ends of the conductor are left entirely insulated or the wire may fall and its insulation may be impaired so that a ground, a cross, or a short also may occur.

b. One or more conductors of a circuit may accidently come in contact with the ground (earth). This fault is called a ground. A very low-resistance ground is known as a direct ground. A high-resistance ground (or high-resistance cross) is known as a leak or escape.

c. Two conductors of a line may accidentally make contact with each other, and, as a result, form a new path for current flow. This fault is called a short circuit.

d. One or both conductors of a line may be in contact with one or more conductors of other lines. This fault is known as a cross.

13. Types of Operation

a. ONLY ONE FAULTY PAIR

(1) Disconnect all equipment from the faulty pair at both ends.

(2) Connect the faulty pair to binding posts T and R of PR-1; use the leads furnished with the test set.

(3) Connect a ground to binding post G. The ground connection may be made to a metal rod driven into the earth or to a grounded pipe or cable system.

(4) Throw lever switch PR-1 to the TEST position, and turn the SELECTOR switch to T-R; also release the galvanometer clamp button.

(5) Maintain communication with the distant end of the section, if possible, with a good pair of wires. Connect the good pair to binding posts T and R of PR-2 on the test set. Connect a telephone to binding posts TEL and throw lever switch PR-2 to the TALK position, thus connecting the telephone to the good line.

(6) Instruct the repair man at the distant end to have the faulty pair clear and open; then measure the insulation resistance between the two conductors (T-R) of the faulty pair and between each conductor (T-G and R-G) and ground (T-G and R-G). Detailed methods of performing these measurements are explained in paragraph 14a and b. A relatively high resistance in all three positions indicates that there is no insulation trouble on the pair under test. A low-insulation resistance reading between two conductors tip and ring may indicate a short circuit between the two conductors of the pair. Low-insulation resistance to ground for either conductor (T-G or R-G) indicates the possibility of a ground or cross on the conductor or conductors for which the reading is low.

(7) If a low reading is obtained, instruct the repair man at the distant end to short-circuit the pair under test. Then measure the loop resistance (par. 15). The resistance per mile can be determined from the resistance data (table I); the loop resistance is known from the measurement just completed. The approximate distance to the end of the line also is known. A simple calculation will indicate whether the loop resistance is nearly correct. For example, if the line is 5 miles long and the loop resistance per mile, according to the resistance data table for the type of cable under test, is 84 ohms, then the loop resistance should be 420 ohms. An excessively high value of loop resistance indicates an open. Excessively low value of loop resistance indicates a short. Thus by loop resistance and insulation resistance tests, it is possible to determine whether the line is open, shorted, or grounded.

b. MORE THAN ONE FAULTY PAIR.

(1) Follow the procedure outlined in subparagraph a above for every faulty pair.

(2) Next, connect one faulty pair to binding posts T and R of PR-1. Remove the ground connection from binding post G and connect in its place both wires from another faulty pair.

(3) Then proceed to measure insulation resistance (par. 14a and b). In this case, however, first measure the insulation resistance between the wire connected to binding post T and the two wires connected to G. This is done by setting the SELECTOR switch at T-G and proceeding with instructions given in subparagraph 14a. A low reading indicates crosses between the wire connected to binding post T and the wire connected to binding post G.

(4) Next, set the SELECTOR switch at R-G and again determine the insulation resistance. A low reading here indicates crosses between the wire connected to binding post R and the wire connected to binding post G. Crosses always should be suspected if the insulation resistance is abnormally low, particularly in the case of multiple-conductor wire or cable, or if trouble develops at the same time in two pairs. In such cases, test for crosses (par. 17b and d). Low-insulation resistance between any two conductors indicates a cross.

14. Measuring Insulation Resistance

a. ONLY ONE FAULTY PAIR.

(1) Open the faulty pair at both ends of the line and disconnect all equipment. Connect the faulty pair to binding posts T and R of PR-1. Connect a good pair, if available, to binding posts T and

TABLE I

TEMPERATURE CORRECTION

(OHMS-PER-LOOP MILE)

	F°	W-110-B	W-130 W-130-A W-130-C WD-3/TT	W-143	W-153	CC-345 CC-355-A	CC-358-E	WD-1/TT WD-14/TT	CX-1065
AVERAGES VALUES	0	162.4	518.2	27.4	18.31	74.1	65.6	179.7	73.4
	10	166.4	535.9	28.1	18.75	76.0	67.3	184.3	75.3
	20	170.5	553.7	28.7	19.20	77.9	68.9	188.9	77.1
	30	174.5	571.5	29.4	19.63	79.8	70.6	193.5	79.0
	40	178.6	589.2	30.1	20.10	81.7	72.3	198.1	80.9
	50	182.7	607.0	30.8	20.55	83.6	74.0	205.5	82.8
	60	186.7	624.8	31.5	21.00	85.5	75.7	207.3	84.7
	68	190.0	639.2	32.0	21.39	87.0	77.0	211.0	86.2
	70	190.8	642.6	32.1	21.47	87.3	77.3	211.9	86.6
	80	194.9	660.1	32.8	21.91	89.3	79.2	216.5	88.5
	90	198.9	678.1	33.5	22.35	91.2	80.7	221.1	90.4
	100	203.0	695.9	34.2	22.80	93.1	82.6	225.7	92.3

Note. Average values vary ±2 percent with those of the manufacturers.

R of PR-2. This latter connection is made so that communication may be maintained between the two test points. For this purpose, connect a telephone to binding posts TEL.

(2) Throw lever switch PR-1 to the TEST position and lever switch PR-2 to TALK position. Set the SELECTOR switch at T-R. This is the position for measuring the insulation resistance between the two wires of the faulty pair.

(3) Depress the push switch marked MEGOHMS. (1 megohm is equal to 1,000,000 ohms.) Keep the push switch depressed and turn the slide-wire dial knob slowly, starting with the knob turned as far as possible in a clockwise direction. As the knob is turned in a counterclockwise direction, the galvanometer needle will deflect to the left. Continue turning the knob until the needle reads zero.

(4) Then read scale D on the calibrated dial. The correct reading is obtained directly in megohms at the dial point exactly beneath the hairline in the transparent window. Scale D is calibrated in megohms from 50 megohms (50,000,000 ohms) down to zero ohms.

(5) When measuring insulation resistances below 100,000 ohms, depress the OHMS X100 push switch instead of the MEGOHMS push switch.

(6) If a reading below 100,000 ohms is obtained, start again with the slide-wire dial knob turned as far as possible in a clockwise direction. This time, depress the OHMS X100 push switch and turn the knob slowly in a counterclockwise direction until the needle reads zero. The reading from scale C, multiplied by 100, yields the insulation resistance in ohms.

(7) By using the OHMS X100 push switch, it is possible to measure resistance accurately below 100,000 ohms down to about 100 ohms. Very low resistance is measured by depressing the OHMS push switch. This push switch is not used for measuring high insulation resistance. If the reading obtained is abnormally low, this indicates a short.

(8) Next, set the SELECTOR switch at the T-G position. This position measures the insulation resistance between the wire connected to binding post T and ground. Follow the same procedure given for the SELECTOR switch set at T-R (subpar. (3) through (7)) above. A low reading in this instance indicates a ground at some point on the wire connected to binding post T.

(9) Repeat the procedure given in subparagraphs (3) through (7) with the SELECTOR switch turned to the R-G position. A low

reading in this position indicates a ground at some point on the wire connected to binding post R.

b. MORE THAN ONE FAULTY PAIR.

(1) Open each faulty pair at both ends of the line and disconnect all equipment. Connect one of the faulty pairs to binding posts T and R of PR-1. Connect both wires of another faulty pair to binding post G. Do not use a ground connection. If a good pair is available, connect the wires of this pair to binding posts T and R of PR-2 and connect a telephone to binding posts TEL. The pair connected to binding posts T and R of PR-2 will then be useful for communicating between the ends of the cable.

(2) Throw lever switch PR-1 to the TEST position and lever switch PR-2 to the TALK position. Set the SELECTOR switch at T-G. This is the position for measuring the insulation resistance between the wire connected to binding post T of PR-1 and the two wires connected to binding post G.

(3) Measure this insulation resistance by following the same general procedure as outlined in subparagraph a above. If a low-resistance reading is obtained, it indicates a cross between the wire connected to binding post G and the wire connected to binding post T.

(4) Next set the SELECTOR switch to R-G and again measure the insulation resistance. If there is a cross between the wire connected to binding post R and the wire connected to binding post G, it will show up as a low-resistance reading.

(5) Repeat the procedure given in subparagraphs (1) through (4) above for other faulty pairs until all have been checked for insulation resistance.

15. Measuring Loop Resistance

a. To measure the conductor resistance of any pair, first clear both ends of all equipment.

b. Next, short-circuit the distant end by using a low-resistance strap or wire or by soldering one bare end to the other. Connect the pair to be tested to binding posts T and R of PR-1 and throw lever switch PR-1 to the TEST position.

c. Set the SELECTOR switch at T-R. Depress the OHMS push switch. Keep the push switch depressed and turn the slide-wire dial knob as far as possible in a clockwise direction. Then turn the knob slowly in a counterclockwise direction until the galvanometer needle reaches the zero point on the scale. The resistance then may be read directly in

ohms on scale C. Values of resistance per mile for different types of wire are given in table I. If the resistance is unduly high, it indicates an open. If the resistance is abnormally low, check for a ground, short, or cross.

d. For measuring conductor resistances above 5,000 ohms or for making more accurate determination of resistance above 500 ohms, use the OHMS X100 push switch instead of the OHMS push switch. The procedure is exactly the same, except that, when the OHMS X100 push switch is depressed, the reading obtained on the scale C must be multiplied by 100 to determine the conductor resistance in ohms.

e. The methods explained in subparagraph a through d above for measuring conductor resistance also may be used to measure resistance of components, such as fixed resistors and potentiometers. To measure resistors from 500,000 ohms up, the MEGOHM push switch is used in conjunction with scale D. The procedure is exactly the same as for measuring insulation resistance, except that the resistor or other component to be measured is connected directly to binding posts T and R of PR-1 or T and R of PR-2.

16. Measuring Capacitance

The line capacitance is measured as follows:

a. First, clear the line of all equipment. Connect one end, tip and ring of the line, to binding posts T and R of PR-1. Have the other end of the line open.

b. Throw lever switch PR-1 to the TEST position. Set the selector at T-R. Depress the OPENS push switch. Keep the push switch depressed and turn the slide-wire dial knob as far as possible in a clockwise direction.

c. Turn the knob slowly in a counterclockwise direction until the galvanometer needle reaches the zero point on the scale.

d. Read scale A. This is divided into 100 equal parts. Note the exact indication on the dial at which zero reading results on the galvanometer, then refer to the capacitance calibration curve (fig. 4) contained on the inside of the lid. From this curve, convert the dial reading into a capacitance value in microfarads. For example, if the dial reading is 70, refer to the point at which the curve passes through 70 and read 1.165 microfarads at the left-hand margin of the chart. The capacitance reading thus obtained is used to determine the location of opens. (Refer to the charts in the lid of the test set and to figures 4 through 12.)

e. It is also possible to check the capacitance of capacitors ranging from approximately .075 microfarad to 3.0 microfarads by using the procedure outlined in subparagraph a through d above. In determining the capacitance of a capacitor, connect the capacitor directly to binding posts T and R of PR-1 or T and R of PR-2 and by throwing the appropriate lever switch.

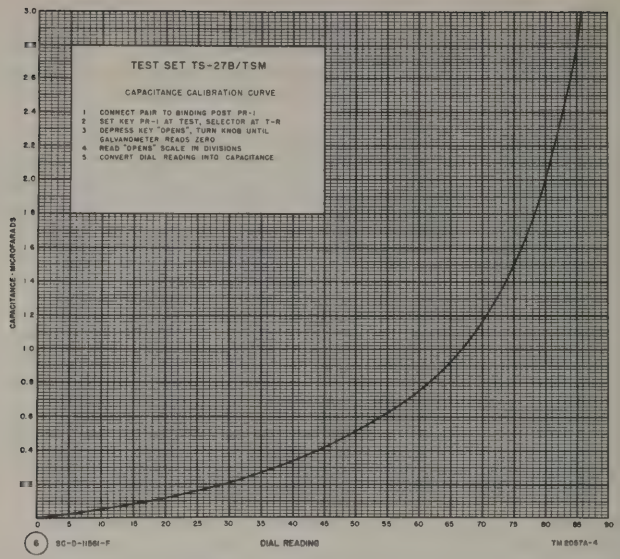

TEST SET TS-27B/TSM
CAPACITANCE CALIBRATION CURVE
1 CONNECT PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 CONVERT DIAL READING INTO CAPACITANCE
CAPACITANCE - MICROFARADS
DIAL READING
SC-D-11561-F
TM 2057A-4

Figure 4. Test Set TS-27B/TSM, capacitance calibration curve.

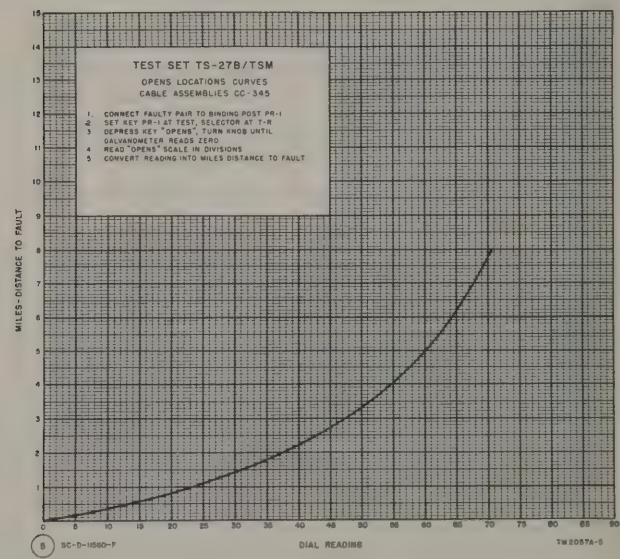

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVES
CABLE ASSEMBLIES CC-345
1 CONNECT FAULTY PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 CONVERT READING INTO MILES DISTANCE TO FAULT
MILES - DISTANCE TO FAULT
DIAL READING
SC-D-11560-F
TM 2057A-3

Figure 5. Test Set TS-27B/TSM, opens location curve for Cable Assembly CC-345.

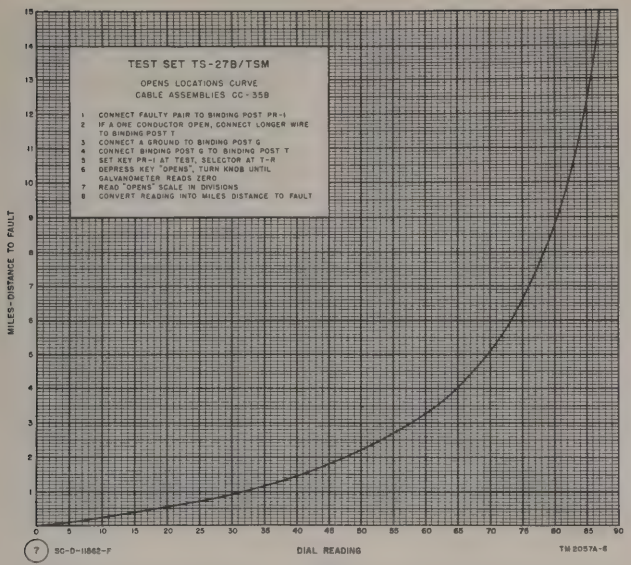

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVE
CABLE ASSEMBLIES CC-358
1 CONNECT FAULTY PAIR TO BINDING POST PR-I
2 IF A ONE CONDUCTOR OPEN, CONNECT LONGER WIRE TO BINDING POST T
3 CONNECT A GROUND TO BINDING POST G
4 CONNECT BINDING POST G TO BINDING POST T
5 SET KEY PR-I AT TEST, SELECTOR AT T-R
6 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
7 READ "OPENS" SCALE IN DIVISIONS
8 CONVERT READING INTO MILES DISTANCE TO FAULT
MILES-DISTANCE TO FAULT
DIAL READING
7
SC-D-11862-F
TM 2057A-6

Figure 6. Test Set TS-27B/TSM, opens location curve for Cable Assembly CC-358-E.

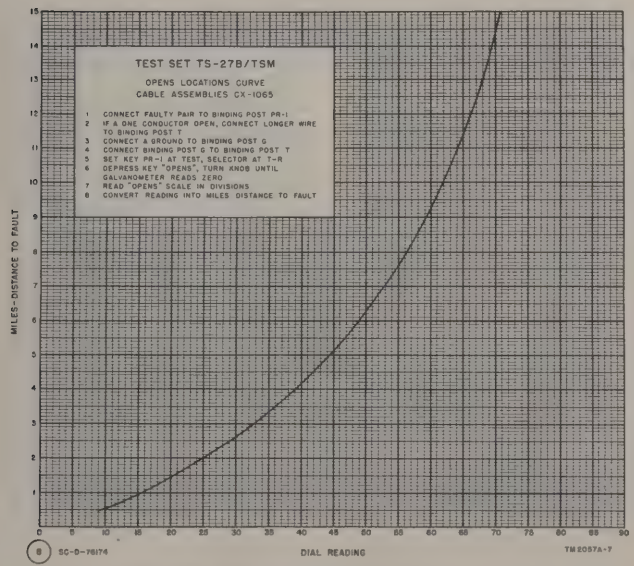

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVE
CABLE ASSEMBLIES CX-1065
1 CONNECT FAULTY PAIR TO BINDING POST PR-I
2 IF A ONE CONDUCTOR OPEN, CONNECT LONGER WIRE TO BINDING POST T
3 CONNECT A GROUND TO BINDING POST G
4 CONNECT BINDING POST G TO BINDING POST T
5 SET KEY PR-I AT TEST, SELECTOR AT T-R
6 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
7 READ "OPENS" SCALE IN DIVISIONS
8 CONVERT READING INTO MILES DISTANCE TO FAULT
MILES-DISTANCE TO FAULT
DIAL READING
8
SC-D-76174
TM 2057A-7

Figure 7. Test Set TS-27B/TSM, opens location curve for Cable Assembly CX-1065.

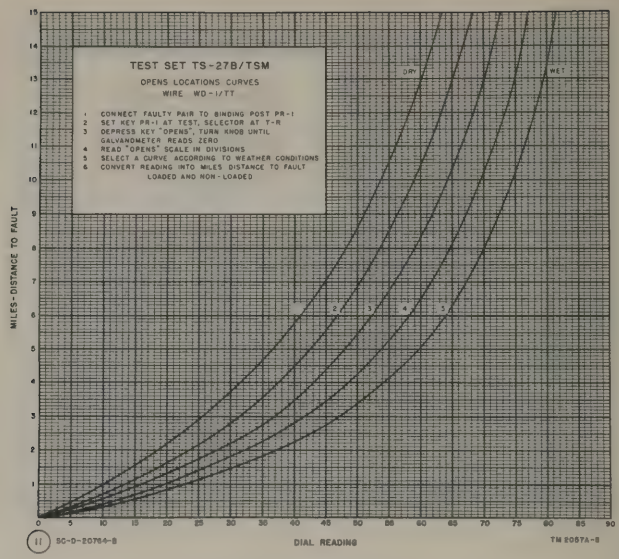

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVES
WIRE WD-1/TT
1 CONNECT FAULTY PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 SELECT A CURVE ACCORDING TO WEATHER CONDITIONS
6 CONVERT READING INTO MILES DISTANCE TO FAULT LOADED AND NON-LOADED
DRY
WET
MILES-DISTANCE TO FAULT
DIAL READING
11 SC-D-20764-B
TM 2057A-8

Figure 8. Test Set TS-27B/TSM, opens location curves for Wire WD-1/TT.

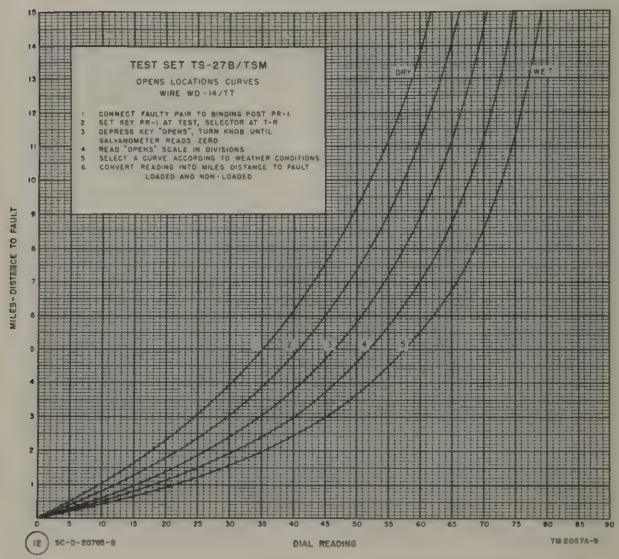

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVES
WIRE WD-14/TT
1 CONNECT FAULTY PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 SELECT A CURVE ACCORDING TO WEATHER CONDITIONS
6 CONVERT READING INTO MILES DISTANCE TO FAULT LOADED AND NON-LOADED
DRY
WET
MILES-DISTANCE TO FAULT
DIAL READING
12 SC-D-20765-B
TM 2057A-9

Figure 9. Test Set TS-27B/TSM, opens location curves for Wire WD-14/TT.

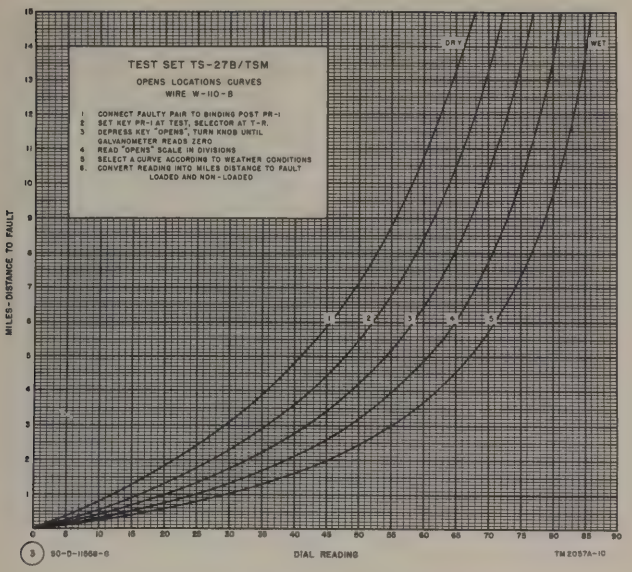

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVES
WIRE W-110-B
1 CONNECT FAULTY PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 SELECT A CURVE ACCORDING TO WEATHER CONDITIONS
6 CONVERT READING INTO MILES DISTANCE TO FAULT LOADED AND NON-LOADED
DRY
WET
MILES - DISTANCE TO FAULT
DIAL READING
SC-D-11558-S
TM 2057A-10

Figure 10. Test Set TS-27B/TSM, opens location curves for Wire W-110-B.

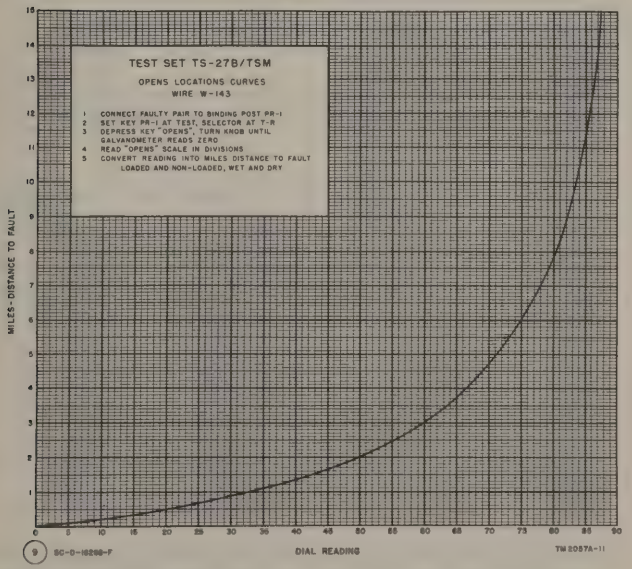

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVES
WIRE W-143
1 CONNECT FAULTY PAIR TO BINDING POST PR-1
2 SET KEY PR-1 AT TEST, SELECTOR AT T-R
3 DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
4 READ "OPENS" SCALE IN DIVISIONS
5 CONVERT READING INTO MILES DISTANCE TO FAULT LOADED AND NON-LOADED, WET AND DRY
MILES - DISTANCE TO FAULT
DIAL READING
SC-D-10268-F
TM 2057A-11

Figure 11. Test Set TS-27B/TSM, opens location curve for Wire W-143.

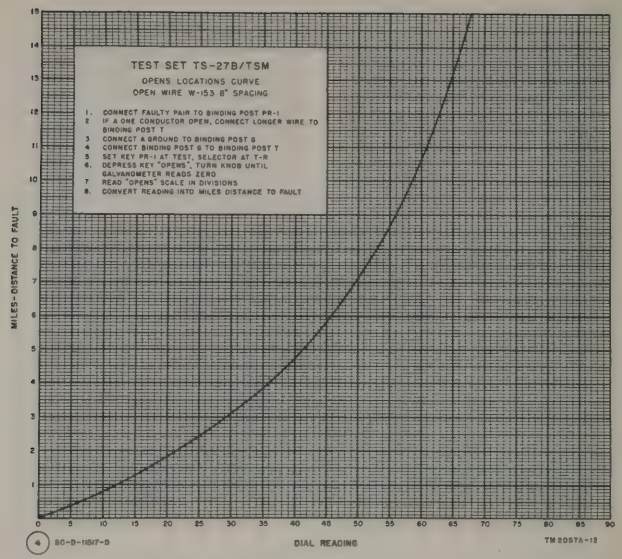

TEST SET TS-27B/TSM
OPENS LOCATIONS CURVE
OPEN WIRE W-153 8" SPACING
1. CONNECT FAULTY PAIR TO BINDING POST PR-1
2. IF A ONE CONDUCTOR OPEN, CONNECT LONGER WIRE TO BINDING POST T
3. CONNECT A GROUND TO BINDING POST G
4. CONNECT BINDING POST G TO BINDING POST T
5. SET KEY PR-1 AT TEST, SELECTOR AT T-R
6. DEPRESS KEY "OPENS", TURN KNOB UNTIL GALVANOMETER READS ZERO
7. READ "OPENS" SCALE IN DIVISIONS
8. CONVERT READING INTO MILES DISTANCE TO FAULT
MILES-DISTANCE TO FAULT
DIAL READING
SC-D-11517-D
TM 2057A-18

Figure 12. Test Set TS-27B/TSM, opens location curve for Wire W-153

17. Determining Location of Faults

a. GROUNDS. After preliminary tests indicate that the fault on a line is due to a ground, determine the location of the ground and remedy the trouble.

(1) First, clear the faulty line of all equipment. Connect the near end of the line to binding posts T and R of PR-1. Short-circuit the distant ends of the line. Maintain telephone communication with the tester at the far end by using a good pair connected to binding posts T and R of PR-2. The method of using the telephone for this purpose is described in paragraph 13a(5) and (6).

(2) Connect a suitable ground to binding post G. Set the SELECTOR switch to GNDS position.

(3) Depress the OHMS push switch. The circuit is now as shown in figure 18.

(4) Throw lever switch PR-1 to the TEST position. Turn the SLIDE-WIRE DIAL knob as far as possible in a clockwise direction.

(5) Keep the OHMS push switch depressed and slowly turn the SLIDE-WIRE DIAL knob in a counterclockwise direction until the galvanometer needle reads zero.

(6) Then read scale B. This scale is calibrated 0-100-0 and indicates the percent of the distance to the fault.

(7) When balance is reached, the scale B gives the distance between the test set and the ground as a percentage of the length of the line under test. When the indication falls in the range 0-100 (left-half of the scale), the ground lies in the conductor connected to binding post T; when the indication is in the 100-0 (right-half of the scale), the ground lies in the conductor connected to binding post R. For example, if a two-conductor cable 2,000 feet long yields a balance at 35 in the 0-100 range, the ground lies in the conductor connected to binding post T and is located .35 by 2,000 or 700 feet from binding post T. It is assumed that the resistance per foot of both conductors is the same and is uniform. The jumper tying the distant ends of the faulty line together must be a good connection, because contact resistance at this point may introduce an appreciable error.

b. SHORTS AND CROSSES (GOOD WIRE AVAILABLE).

(1) Short circuits and crosses are located as special cases of grounds. If a short circuit is indicated between two conductors, and a good conductor (of a paralleling pair) is available, use binding posts T and R of PR-1, with the good conductor connected to binding post R. Connect one side of the faulty wire to the T binding post and the other side of the faulty wire to binding post G. The second wire of the good pair is not used.

(a) At the far end of the faulty pair, connect a jumper between the ends of the wires which terminate at binding posts T and R of PR-1.

(b) Throw lever switch PR-1 to the TEST position, set the SELECTOR switch to the GNDS position, depress the OHMS push switch, and follow exactly the same procedure outlined in subparagraph a(5) and (6) above. The percent read on scale B at balance, multiplied by the length of the line, will give the distance from the test set to the short circuit. The good conductor of the paralleling pair must have the same resistance as that of each conductor of the shorted pair.

(2) Crosses are located in the same manner as shorts. One side of the good wire is connected to binding post R, and one side of the faulty wire is connected to binding post T; the second wire of the faulty pair is connected to binding post G. The second wire of the good pair is not used. Follow the same procedure

as outlined in subparagraph b(1) above; multiply the length of the line by the percent reading at balance, to obtain the distance from the test set to the fault. Conductors of a pair being measured are assumed to have equal resistance.

c. SHORT CIRCUITS (NO GOOD WIRE AVAILABLE). If no good conductor is available for locating shorts, an alternative approximate method must be used.

(1) Connect shorted wires to binding posts T and R of PR-1. Make no connection to post G. Clear the two wires of all equipment, leaving the distant ends open.

(2) Then follow the procedure outlined in paragraph 15 for measuring conductor resistance with the SELECTOR switch at T-R and the OHMS push switch depressed. Take readings in ohms on scale C. Values of loop resistance per mile for different types of wire are given in table I. Divide the ohms reading by the resistance per mile, thus determining the distance in miles to the fault. The accuracy of this determination depends on the resistance of the fault. The lower the resistance of the fault itself, the more accurate the result. Usually the location determined in this manner will appear to be beyond the actual fault.

d. CROSSES (NO GOOD WIRE AVAILABLE). This alternate method of locating crosses is only approximate.

(1) Connect the faulty wire of the first pair to binding post R of PR-1. Connect the faulty wire of the second pair to post T of PR-1. Clear both pairs of wires of all equipment, leaving the distant ends open. Do not connect anything to binding post G.

(2) Throw lever switch PR-1 to the TEST position. Set the SELECTOR switch at T-R and depress the OHMS push switch.

(3) Follow the procedure outlined in paragraph 15 for measuring conductor resistance. Take readings in ohms on scale C. Divide the readings thus obtained by the loop resistance per mile, as obtained from table I. The result will give the approximate distance in miles to the fault. Here again, the lower the resistance of the cross, the more accurate the result. The location as determined from this test will usually appear to be beyond the actual fault.

e. OPENS. Opens generally are located by converting a dial reading to distance in miles to the open, by reference to a calibration curve. In general, the open pair is connected to binding posts T and R of PR-1. In order to reduce the variations of capacitance with respect to ground, binding post G is grounded and connected to one side of the open pair, and to the good side when the open is in one conductor only. The sheath

of the cable, if any, and the other conductors are all grounded or left floating according to the method used in collecting the data from which the chart was prepared. Separate curves are furnished in the chart assembly in the lid of the case for Wires W-110-B, W-143, WD-1/TT, and WD-14/TT, and for spiral-four Cable Assembly CC-358-E, five-pair rubber Cable Assembly CC-345, spiral-four Cable Assembly CX-1065 and open Wire W-153 with 8-inch spacing. In addition, blank curve sheets are provided in the chart assembly for plotting facilities that do not have calibration curves. The data for these curves is obtained experimentally by measuring and plotting the capacitance of known lengths of the facilities. The following specific instructions for locating opens apply to those facilities for which calibration curves are available:

(1) Opens in Wire W-110-B, WD-1/TT or WD-14/TT.

(a) When testing this type of wire for opens, connect the two sides of the open pair to binding posts T and R of PR-1 and throw lever switch PR-1 to TEST. Clear the wires under test of all equipment and have the distant end open. A ground is not necessary in this test.

(b) Set the SELECTOR switch at T-R. This is the selector position used for all opens tests. Turn the SLIDE-WIRE DIAL knob until scale A reads zero.

(c) Then, with the OPENS push switch depressed, slowly turn the slide-wire dial knob in the opposite direction. When a balance is obtained, as indicated by a zero reading of the galvanometer, read dial A in divisions. This procedure is called taking an opens reading.

(d) Estimate the moisture condition of the wire under test and select one of the five curves shown on opens location curves for Wire W-110-B. Curve 1 applies when the wire is very dry, curve 5 when the wire is very wet, and curves 2, 3, and 4 apply for intermediate conditions.

(e) Translate the opens reading into distance in miles to the fault by means of the curve selected.

(f) Dispatch a repair man to the location and cut the line nearest the fault. Take another reading on this new open and then, knowing the actual distance that this open is from the testing point, determine a better curve for the condition of the line by locating this point on the curve sheet.

(g) Close the line at the point where it was cut and take a second reading. Knowing the proper curve, a more accurate location of the actual fault can be made.

(h) Then send the repair man to investigate conditions at this new location. If a paralleling good line is available, a known length of this line may be used to determine the appropriate curve. To do this, take an opens reading on this known length of line and locate the point on the curve sheet, thus determining the curve. This point may fall between two curves, in which case it is necessary to consider that other dial readings also will be at points similarly situated between the same two curves.

(2) Opens in spiral-four Cable Assembly CC-358-E or CX-1065.

(a) Connect the open pair to binding posts T and R of PR-1. If the open is in one conductor only, connect the good wire to binding post T.

(b) Connect a ground to binding post G; connect binding post G to binding post T; also connect the remaining pair and the steel braid to binding post G. If the conductors of the remaining pair are not accessible for grounding, they may be left floating without excessive error.

(c) Set lever switch PR-1 at TEST and set the selector switch at T-R. Depress the OPENS push switch and turn the knob of the slide-wire dial until the galvanometer reads zero.

(d) Read scale A in divisions and convert the dial reading into distance in miles to the open by the opens location curve for Cable Assembly CC-358-E. Since the capacitance of this type of cable is relatively stable with moisture conditions, only one calibration curve is necessary.

(3) Opens in Cable Assembly CC-345.

(a) To locate opens in five-pair, rubber-covered cable, connect the open pair to binding posts T and R of PR-1 and ground binding post G. Strap T or R of PR-1 to binding post G. In the case of a single-conductor open, the conductor strapped to G should be the good one.

(b) Set lever switch PR-1 at TEST and the selector switch at T-R. Depress the OPENS push switch and turn the SLIDE-WIRE DIAL knob until the galvanometer reads zero.

(c) Read scale A in divisions and convert this reading into distance in miles to the open using the opens location curve for Cable Assembly CC-345.

(d) Use this same procedure (subpars. (a) through (c) above) for locating opens in 10-pair, rubber-covered cable, such as Cable Assembly CC-355-A.

(4) Opens in open wire lines.

(a) To locate opens in open wire lines, connect the open pair to binding posts T and R of PR-1 and ground binding post G. If the fault consists of an open in one side only, connect the good side to binding post T. Connect binding post G to binding post T.

(b) Set lever switch PR-1 at TEST and the SELECTOR switch at T-R. Depress the OPENS push switch, turning the knob of the slide-wire dial until the galvanometer reads zero.

(c) Read scale A in divisions and convert the reading into distance in miles using the curve applying to the open wire line used. Since the capacitance per mile of an open wire line is considerably less than that of the cables, the dial reading for faults the same distance away will be lower.

(d) The 8-inch spacing curve for Wire W-153 (fig. 12) provides a means of converting the dial reading to the number of miles to the open for one of the more common types of open wire line. The curve for W-143 open wire line provides similar information for this facility. Data for curves for other types of lines may be obtained experimentally by taking opens readings on five or six opens inserted for the purpose at various distances from the test set. Blank curve sheets are provided in the lid of the chart assembly case for plotting such curves.

18. Stopping Procedure

a. Lock the galvanometer movement by means of the clamp (par. 9c).

b. Disconnect the test leads or the patch cord from lines being tested.

c. Replace the test leads and the patch cord in the test lead compartment of the test set.

d. Place the charts inside the holder in the lid.

e. Place the lid over the case, and secure the lid to the case by means of the four spring latches.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

19. General

The operation of Test Set TS-27B/TSM may be difficult in regions where extreme cold, heat, humidity and moisture, sand conditions, etc., prevail. In the following paragraphs instructions are given on procedures for minimizing the effect of these unusual operating conditions.

20. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather affect the efficient operation of the equipment. Instructions and precautions for operation under such conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry. If the set is not in a heater inclosure, and capacitance measurements or open tests have to be made, be sure to allow ample time for the tubes to warm up properly. As can be seen on the circuit diagram (fig. 20), the filament current is supplied through the contacts of the OPENS push switch S1. When this switch is in a normal nonoperated position, it keeps the tubes from being lighted when the set is not in use. To preheat the tubes, it must be held operated manually.

c. When equipment which has been exposed to the cold is brought into a warm room, it will start to sweat and will continue to do so until it reaches room temperature. When the equipment has reached room temperature, dry it thoroughly. This condition also arises when equipment warms up during the day after exposure during a cold night.

d. Use any improvised means to protect dry batteries, since they will fail if not protected against cold. Preheat the batteries. To prevent heat loss, place them in bags lined with kapok, spun glass fiber materials, animal skins, or woolen clothing.

21. Operation in Tropical Climates

When operated in tropical climates, particularly in swampy areas, moisture conditions are more acute than normal. Ventilation is usually very poor, and the high relative humidity causes condensation of moisture on the equipment whenever the temperature of the equipment becomes lower than the ambient air. To minimize this condition, place lighted electric light bulbs under the equipment wherever possible.

22. Operation in Desert Climates

a. Conditions similar to those encountered in tropical climates often prevail in desert areas. Use the same measures to insure proper operation of the equipment.

b. The main problem which arises with equipment operation in desert areas is the large amount of sand or dust which enters the moving parts of the equipment. Make frequent preventive maintenance checks and endeavor to keep the equipment covered as much as possible. See chapter 3 for preventive maintenance checks.

CHAPTER 3

ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. PREVENTIVE MAINTENANCE SERVICES

23. Tools and Equipment Supplied with Test Set TS-27B/TSM

Special tools or sets are not supplied with Test Set TS-27B/TSM. Two vacuum tubes, 1LN5 and 3Q5GT, are the only spares supplied with the test set.

24. Definition and Importance of Preventive Maintenance

a. DEFINITION. Preventive maintenance is work performed on equipment, usually when not in use, to keep it in good working condition so that break-downs and needless interruptions in service will be kept at a minimum. The object of preventive maintenance is to eliminate the need for trouble shooting and repair.

b. IMPORTANCE. Since the failure or inefficient operation of even one component may cause the break-down of the entire equipment, the importance of preventive maintenance is obvious. Operators must maintain equipment placed in their charge in such condition that it will work at top efficiency at all times.

25. Performing Preventive Maintenance

a. GENERAL. Every 6 months, the test set should be inspected completely and the necessary preventive maintenance measures taken. Follow the procedure given in subparagraphs c through e below.

b. TOOLS AND MATERIALS REQUIRED FOR PREVENTIVE MAINTENANCE.

Tool or material	Signal Corps stock No.
Cheesecloth, bleached (lint free)	6Z1989
Cloth, crocus	6Z2000
Screwdriver TL-467/U	6R15371
Solvent, dry-cleaning (SD)	QM 51-S-4381-1 (Quartermaster stock number)
Sandpaper #0000	6Z7500-0000
Brush, soft bristle	CE 38-3706.400-130

Note. Gasoline will not be used as a cleaning fluid for any purpose.

c. REMOVING BRIDGE FROM CASE.

(1) Preparing working area. Prepare a clean place to set the instrument once it has been removed from the case. When placing the instrument chassis on the prepared surface, be sure no projections or pointed objects are underneath the panel. See that no metal filings are near to, or located above, the exposed wiring and internal parts of the capacitance resistance bridge. Filings, which can cause electrical short circuits, can fall accidentally into the chassis as a result of vibration or an inadvertent arm movement by the maintenance personnel.

(2) Removing chassis from case. Unscrew the four panel mounting screws. Lift out the chassis by grasping the handles, and carefully place the chassis panel down on the prepared working surface.

d. PREVENTIVE MAINTENANCE PROCEDURES.

(1) Cleaning. Clean the entire chassis with a clean lint-free cloth. Use a small camel's-hair brush on the parts that are not accessible for cleaning with the cloth. Remove dirt or oil with solvent (SD). Clean the switch contacts with the cloth; use solvent (SD) if further cleaning is necessary. Thoroughly polish the insulation between the binding posts. Clean the contact arm of the resistor R22 and be careful to avoid damaging the sliders or resistance wire. Remove all traces of lint after cleaning.

(2) Tightening. Tighten the mounting screws on switches S1 to S7 inclusive. Do not use excessive force. Tighten all the set-screws in the knobs and variable resistor shafts. Tighten the capacitor mounting screws. Be careful when working near the rheostat resistor R22 windings; a slip of the tool may damage the windings beyond use. Check the binding posts for loose connections and tighten if necessary.

(3) Inspection. After cleaning and tightening, inspect the entire chassis for poorly soldered joints, misalinement of parts, and lack of tension in the resistor R22 contact arm and the switch brushes. Do not alter the position of the blades on switches. Check for positive contact on the switch arms. Do not bend the arms for the purpose of making a more firm contact.

e. REPLACING CHASSIS IN CASE. Before replacing the chassis into the case, perform the following:

(1) Clean the case interior thoroughly. Remove any residue in the battery compartment with a damp cloth, and then rub down the battery compartment with a slightly oily cloth.

(2) Set the bridge chassis into the case. Replace the four screws in the panel and tighten the panel.

(3) Measure the battery voltages. If batteries are less than rated under load, replace them with fresh cells.

(4) Replace the battery cells and battery compartment.

26. Preventive Maintenance Checklist

Item No.	What to check	When to check	How to Check	Precautions
1	Exterior (general)	Weekly	Inspect for dirt, dust, corrosion, loose, or missing screws, scratches on panels, broken or chipped meter glass, or loose binding posts. Tighten loose screws and replace any that are missing.	Tighten screws snugly, but do not use force.
			Clean with a dry cloth moistened with solvent (SD) to remove oil, grease, or foreign matter.	
			Wipe dry with a clean cloth.	Remove all traces of lint.
			Polish panel surfaces.	
2	Interior (general)	Semiannually	Inspect all visible parts for evidences of overheating; position of leads and cabling; dirt, corrosion, or other foreign matter; and loose connections.	In tropical and high-humidity locations, look for fungus growth and mildew.
			Tighten all knobs and shafts secured with setscrews. Screw solder lugs down tight.	Avoid excessive pressure.

			Remove dirt, oil, and other foreign matter from all smooth surfaces, using a clean lint-free cloth. Use a brush to remove dust from recesses that cannot be reached with the cloth. Remove dirt, grease, or oil with solvent (SD).	Be careful not to displace circuit elements and wires when cleaning. Do not use abrasives. Remove all traces of lint.
3	Interior (specific) (fig. 20)	Semiannually	Tighten the mounting screws of switches S1 through S7. Tighten binding posts if connections are loose.	Do not use excessive pressure. Be careful when working near resistor R22 windings; the slip of a tool may damage the winding and make it useless. Do not alter the position of the blades on switches.
			Check for positive contact on the arms of switches. Check tension of arms.	Do not bend the arms.
			Clean contacts with a clean dry cloth; use solvent (SD) if necessary.	
			Wipe contact surfaces of resistor R22 contact arm.	Be careful not to damage slider or resistor windings. Remove all traces of lint after cleaning.
			Measure battery voltages, which should be as rated under load. If the voltage is less than rated under load, replace battery with fresh cells and hook up as described in paragraph 42.	

Section II. LUBRICATION AND WEATHERPROOFING

27. Lubrication

Test Set TS-27B/TSM does not require any lubrication.

28. Weatherproofing

a. GENERAL. Signal Corps equipment, when operated under severe climatic conditions, such as prevail in tropical, arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. TROPICAL MAINTENANCE. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13 and TB SIG 72.

c. WINTER MAINTENANCE. Special precautions necessary to prevent poor performance or total failure of equipment in extremely low temperatures are explained in TB SIG 66.

d. DESERT MAINTENANCE. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75.

29. Refinishing

When the finish on the case has been badly scarred or damaged, touch up the outer surface to prevent corrosion of the metal. The scarred surface should be cleaned down to the bare metal with #000 sandpaper; obtain a bright, smooth finish. The bare spots should then be touched up with suitable paint.

CAUTION: Do not use steel wool. Minute particles of steel wool may enter the case and cause electrical shorting or grounding of the circuits.

Section III. TROUBLE SHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

30. General

The trouble shooting and repair that can be performed at the organizational level (operators and repairmen) is necessarily limited in scope to the replacement of defective or discharged batteries, and to the replacement of the two vacuum tubes used in the test set. Trouble shooting procedures given in this section are therefore restricted to the determination of these deficiencies.

31. Checking Batteries

Test Set TS-27B/TSM is provided with two 45-volt Batteries BA-59, one 4-1/2-volt Battery BA-31, and either a 1-1/2-volt Battery BA-15-A or two 1-1/2-volt Batteries BA-30. Remove the battery compartment cover (fig. 3), and remove the batteries from the battery compartment; do not disconnect the batteries from the test set. Use a 20,000 ohms per volt, voltmeter, to measure the battery voltages while the test set is in use. Push down the OPENS push switch, and measure the battery voltages. Replace the new batteries in the test set if the voltage readings are less than 1.2 volts for the BA-15A or BA-30, less than 4.0 volts for the BA-31 or less than 40 volts for the BA-59. (See par. 42 for the removal and replacement of batteries.)

32. Replacement of Vacuum Tubes

Test Set TS-27B/TSM is provided with two spare vacuum tubes, one for each tube used in the set. The spare tubes are mounted in spare sockets, which are secured to the case by means of a mounting bracket. Check the operation of the unit by means of the equipment performance checklist (par. 33). If the unit fails to operate, check the battery voltages (par. 31) and, if necessary, replace batteries. Again, check operation of the test set. If the unit fails to operate properly, inspect the unit as described in paragraph 25d(3). Should this inspection show no visible signs of damage, remove the vacuum tubes one at a time from their sockets in the chassis, and substitute the spare tubes from the spare sockets. If the equipment still is not operating properly, forward the unit to an authorized depot for repair.

33. Trouble Shooting, Using Equipment Performance Checklist

The equipment performance checklist is used to determine whether Test Set TS-27B/TSM is functioning properly. Items 1 through 6 are checked before starting, item 7 when starting, and items 8 through 10 when stopping. The information given under the action or condition column represents the control setting at which the item is to be checked, or action that must be taken in order to check the normal indication given in the normal indication column. The normal indications listed include the visible signs the operator will perceive when he checks the items. If the indications are not normal, the operator should apply the recommended corrective measures. The corrective measures listed are those that the operator can make without turning the equipment in for repairs. If the equipment will not operate, or if the recommended corrective measures do not yield the desired results, turn the equipment in for repair by properly authorized personnel.

33. TROUBLE SHOOTING, USING EQUIPMENT PERFORMANCE CHECKLIST (contd)

Item No.	Item	Action or condition	Normal Indication	Corrective measures
1	Galvanometer	Set unit on level surface, unclamp galvanometer clamp.	Galvanometer needle stops in center at zero.	Set needle at zero (par. 9d)
2	R22	Set dial to left end of scale.		
3	S7	Set to T-R, R-G, or T-G.		
4	S4	Depress "MEGOHMS" switch.		
5	R22	Move knob slowly counterclockwise.	Galvanometer deflects to left slowly and smoothly.	Defective R22; see see trouble shooting chart (par. 38).
6	S5, S6, S1	Repeat step 5 with S1, S5, and S6 depressed in turn, one at a time.	Galvanometer deflects to left slowly and smoothly.	Defective R22; see trouble shooting chart (par. 38).

CHAPTER 4

THEORY

34. General Theory

Test Set TS-27/TSM utilizes a modification of the Wheatstone bridge principle.

a. ELEMENTARY WHEATSTONE BRIDGE. This consists of four arms connected in a closed circuit (fig. 13). In the elementary bridge, three arms, R_1, R_2, and R_3, are known adjustable resistors, and the fourth, R_4, is the unknown resistor. A battery is connected across the opposite corners of the bridge, A and B. A galvanometer is connected across the other opposite corners, C and D. The purpose of the Wheatstone bridge is to make certain electrical measurements, chiefly measurements of resistance. To accomplish this purpose, the bridge must be balanced. The bridge is balanced when no current flows through the galvanometer. In the elementary bridge, balance is attained by varying any one or all of the three adjustable known resistors until the galvanometer reads zero. When this balanced condition is reached, the unknown resistance, R_4, is equal to the product of the two adjacent resistors divided by the remaining non-adjacent resistance. Expressed in the form of an equation:

$$\text{Unknown resistance } (R_4) = \frac{R_1 \times R_3}{R_2}$$

Since R_1, R_2, and R_3 are known, R_4 can be determined simply by multiplication and division.

b. SLIDE-WIRE WHEATSTONE BRIDGE. Test Set TS-27B/TSM utilizes a slide-wire (fig. 14) in place of the adjustable resistances, R_2 and R_3, of figure 13. The slide-wire is of uniform resistance throughout its length. In the test set, the slide-wire is potentiometer R22 (fig. 15). A stationary contactor is pressed against this wire by a spring. A control knob turns a drum upon which the slide-wire is mounted. As the knob is turned, a point is located where the galvanometer shows

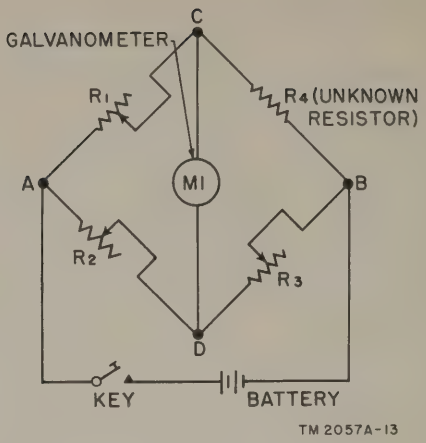


Figure 13. Elementary Wheatstone bridge circuit.

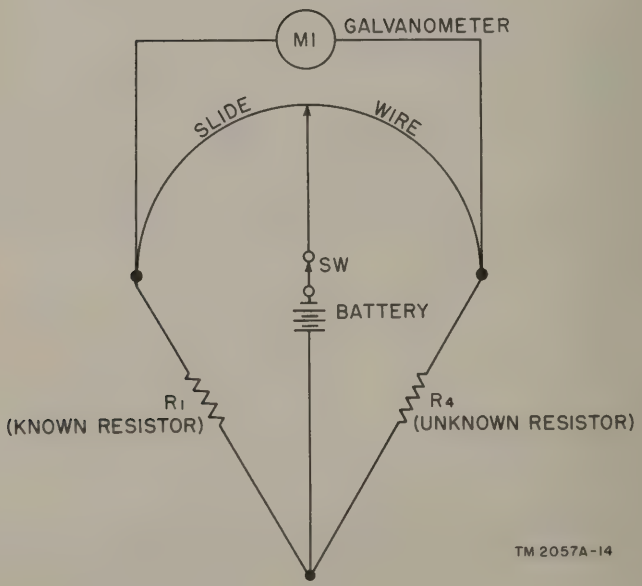


Figure 14. Elementary slide-wire Wheatstone bridge circuit.

no deflection. A calibrated dial, visible in a transparent window, rotates with the drum and the wire. The scale is read directly below a fine wire marker in the window of the dial. The unknown resistance, R_4, may be calculated as explained above from the equation:

$$R_4 = \frac{R_1 \times R_3}{R_2} = \frac{R_1\, l_3 r}{l_2 r} = \frac{R_1\, l_3}{l_2}$$

where r is the resistance per unit length of the slide-wire, and l_2 and l_3 are, respectively, the lengths of the slide-wire corresponding to R_2 and R_3. This makes it possible to use a fixed resistance at R_1, and to calibrate the slide-wire scale so that the value of unknown resistance may be read directly in megohms or ohms from the position of the pointer or marker on the wire or scale. This has been done in Test Set TS-27B/TSM.

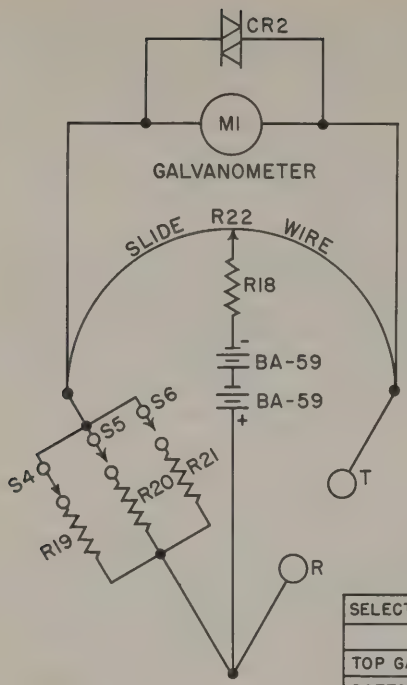
35. Circuit Analysis

The circuit of Test Set TS-27B/TSM (fig. 20) can be subdivided into five basic circuits. The four positions of the SELECTOR (S7) switch provide four of these circuits. The fifth circuit is obtained with the SELECTOR switch in the T-R position and with the OPENS push switch depressed.

a. SELECTOR SWITCH AT T-R.

(1) This circuit (fig. 15) shows the connections used for measuring insulation and conductor resistance. The 20,000-ohm resistor, R18, in series with the battery, serves to limit the battery current, thus protecting the battery and the circuit. Varistor CR2, shunted around the galvanometer, protects the meter from overvoltage. As the voltage across the varistor rises, its resistance decreases rapidly, thus shunting most of the current around the galvanometer. As the voltage across this varistor approaches zero, its resistance becomes very high and the shunting effect is negligible. Nonessential elements have been left out of the diagram (fig. 15) to make it easier to understand.

(2) Switch S4 is shown depressed or closed. This connects the 1-megohm resistor, R19, in the circuit as an arm of the bridge. Therefore, scale D must be read when the bridge is balanced. If it is desired to connect the 10,000-ohm resistor, R20, in place of resistor R19, press OHMS X100 push switch S5 instead of S4 and read scale C, multiplying the reading by 100. Sim-



SELECTOR SWITCH S7 IN T-R POSITION	
	SWITCH CONTACTS
TOP GANG	FROM 2 TO 4 & FROM 8 TO 9
BOTTOM GANG	FROM 5 TO 6

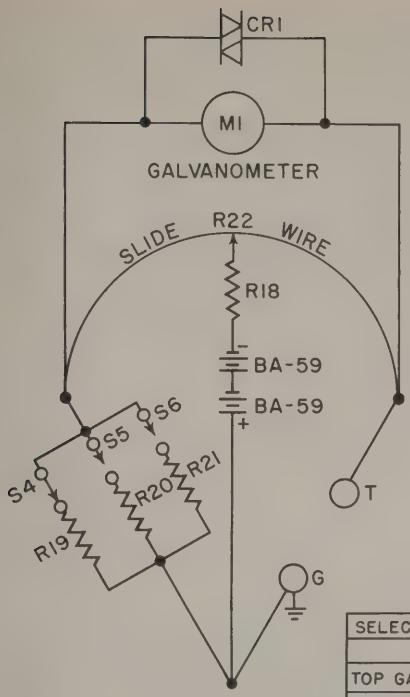
TM 2057A-15

Figure 15. Circuit for measuring insulation and conductor resistance.

ilarly, the 100-ohm resistor, R21, may be substituted by depressing OHMS switch S6. In this case scale C reads directly in ohms. This flexible arrangement permits the same basic bridge circuit to be used for measuring both high and low resistance. With the selector in the T-R position, no external ground is connected to the bridge.

b. SELECTOR AT T-G. The second basic circuit (fig. 16) is obtained by setting the selector at T-G and depressing switch S6, S5, or S4. In this circuit, ground post G is connected as shown, making it possible to measure any resistance connected between binding post T and ground. It is assumed that an external ground is connected to the ground binding post.

c. SELECTOR AT R-G. The third basic circuit (fig. 17) is obtained with the selector at R-G and with switch S4, S5, or S6 depressed. This circuit is identical with the second basic circuit except that binding post T is replaced by binding post R, thus making it possible to measure insulation resistance between the line connected to R and ground.



SELECTOR SWITCH S7 IN T-G POSITION	
	SWITCH CONTACTS
TOP GANG	FROM 2 TO 4
BOTTOM GANG	FROM 5 TO 6 & FROM 2 TO 3

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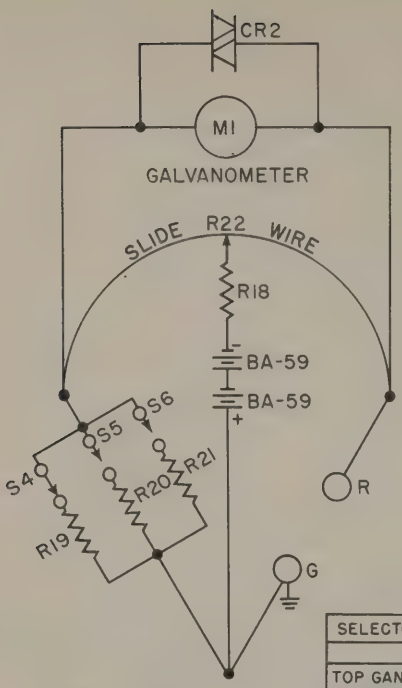
Figure 16. Circuit for measuring insulation resistance between line connected to post T and ground.

d. SELECTOR AT GNDS.

(1) The fourth basic circuit (fig. 18) is obtained with the selector switch at GNDS position and with OHMS key depressed. In this circuit, ground post G is connected to the positive terminal of the battery, binding post T is connected to one end of the slide-wire, and post R is connected to the other end of the slide-wire. No standard resistance arm, such as R19, R20, or R21, is used in this circuit. This circuit, known as the Murray loop, offers a convenient method of locating grounds.

(2) A line suspected of having a ground is connected between binding posts T and R, the ends of the line being clear and shorted. From the diagram it can be seen that the portion of the line between post T and the ground form one arm of the bridge; the portion of the line between post R and the ground form a second arm of the bridge. The third and fourth arms are supplied by the sections of the slide-wire itself. When the bridge is bal-



SELECTOR SWITCH S7 IN R-G POSITION	
	SWITCH CONTACTS
TOP GANG	FROM 9 TO 11
BOTTOM GANG	FROM 5 TO 6 & FROM 2 TO 3

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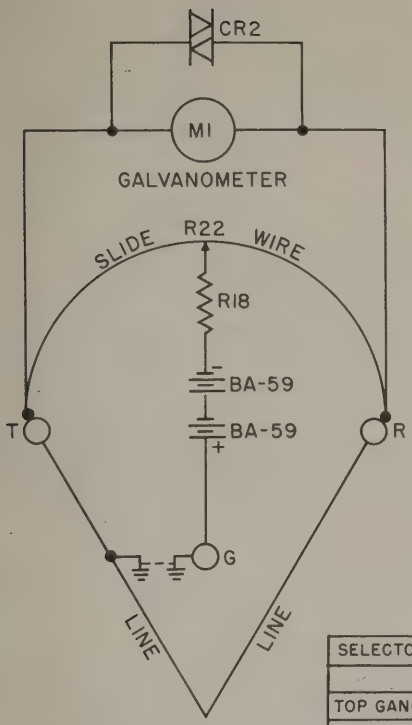
Figure 17. Circuit for measuring insulation resistance between line connected to post R and ground.

anced, the distance from the testing end to the fault is obtained by reading dial B in percent and multiplying this by the length of the line. The exact details utilized in making the Murray loop test are given in subparagraphs a and b above.

(3) This circuit is also suitable for use in determining the location of crosses. All the above-mentioned four basic circuits use 90-volt battery (two 45-volt Batteries BA-59 in series) as the source of energy for the bridge.

e. MEASUREMENTS WITH SELECTOR AT T-R POSITION AND OPENS KEY DEPRESSED.

(1) The arrangement of the circuit under these conditions is shown in figure 19. From this diagram, it may be seen that the bridge is now basically a capacitance bridge because of the standard capacitor C10. Power at 20 ±3 cps (cycles per second) is sup-



SELECTOR SWITCH S7 IN GROUND POSITION	
	SWITCH CONTACTS
TOP GANG	FROM 4 TO 5 8 FROM 9 TO 11
BOTTOM GANG	FROM 2 TO 5

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Figure 18. Murray loop circuit.

plied by the oscillator and amplifier to the bridge. The output from the bridge is converted to direct current by the copper-oxide varistor CR1, connected as a modulator. Resistors R13, R14, R15, R16, and R17 constitute a terminating and balancing network for the modulator. Variable resistor R14 provides the means for adjusting the galvanometer M1 to zero deflection when the slide-wire resistor R22 is set at zero and terminals T and R are open-circuited. The frequency of the oscillator is set by means of variable resistor R1.

(2) The bridge is made to balance, when an unknown combination resistance and capacitance is connected across terminals T and R, by virtue of the combined action of the bridge, the phase-shift network, and the modulator. The phase-shift network includes circuit elements R11, C8, R12, and T1. Potentiometer R12 controls the phase of the voltage output from terminals 4-5 of transformer T1. When R12 is adjusted properly, the bridge will yield the correct indication of the equivalent parallel ca-

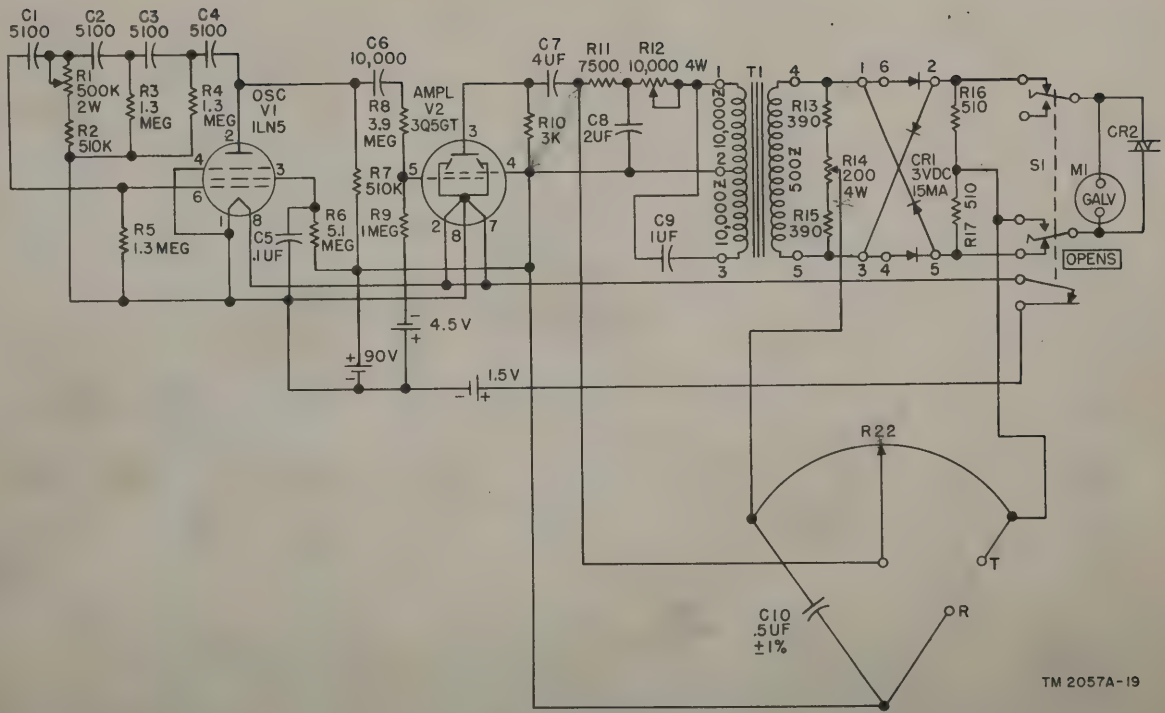

Figure 19. Test Set TS-27B/TSM, schematic diagram of a-c test circuit.

pacitance of any circuit connected across terminals T and R, regardless of the resistance component of the unknown, provided that the power factor of the unknown does not exceed 25 percent, or the time constant, RC, is not less than .030 seconds, Capacitor C9 adjusts the transformer circuit to the impressed frequency.

(3) When the set is adjusted properly, and the slide-wire dial is rotated until the galvanometer indicates zero, the voltage across the terminals of the slide-wire is generally not zero. However, that voltage is then exactly 90° out of phase from the voltage that appears across terminals 4-5 of the transformer T1. Under these conditions, the operation of the modulator is such that zero direct current is delivered to the galvanometer, and balance is indicated.

(4) Plate voltage of 90 volts is impressed across vacuum tubes V1 and V2 from the positive terminal of Battery BA-59, plug P3 through terminal A of plug P1 and terminal A of receptacle J1, and through resistors R7 and R10 respectively. This plate voltage is present across the two vacuum tubes at all times. However, due to the OPENS push switch not being closed, the tubes are not operating because of the absence of filament voltage.

(5) When the OPENS push switch is depressed, the filament circuit for the vacuum tubes is closed from the positive side of the BA-15-A battery through terminal C of the P1 plug and terminal C of the J1 receptacle, through the outside make contact of the OPENS push switch, terminals 7 and 2 of V2, and terminal 8 of V1, back to the negative side of BA-15-A from terminal 1 of V1 and terminal 8 of V2 through terminal B of receptacle J1 and terminal B of plug P1 to the negative side of plug P2.

(6) The closing of the filament circuit also applies to the plate voltage across the oscillator (V1) feedback circuit, which consists of capacitors C1, C2, C3, and C4, and resistors R1, R2, R3, R4, and R5. As a result, the oscillator circuit gives rise to an alternating current with a frequency determined by the time constant of the feedback circuit. The feedback circuit components are selected so that the current through the plate circuit of tube V1 will have a frequency of 20 cps. Small adjustments in the oscillator frequency may be made by varying the setting of resistor R1.

(7) The output of oscillator tube V1 is coupled to the control grid of tube V2 through capacitor C6 and resistor R8. A negative bias is maintained on the control grid of V2 by having the negative terminal of the 4.5-volt Battery BA-31 connected to the grid through terminals G of plug P1 and receptacle J1, and through resistor R9. Vacuum tube V2 is connected as an amplifier.

(a) Lever switch S2 is provided with 12 contacts, four of which are not used. The contacts are arranged in four groups of three contacts each. The center contact of each group is movable. One pair of center contacts is connected to binding post T of PR-1, and the other is connected to binding post R of PR-1.

1. When lever switch S2 is moved to the TALK position, the center movable contacts will close the circuit from T and R of PR-1 to the pair of terminals marked TEL. If a telephone is connected to the binding post marked TEL, lever switch S2 in the TALK position will make it possible to talk over a line connected across binding posts T and R of PR-1.

2. When lever switch S2 is moved to the TEST position, the center contacts establish the circuit from binding posts T and R of PR-1 to the top section of SELECTOR switch S7 through terminals D and F of plug P1 and receptacle J1. Connections are made through the SELECTOR switch (S7) as described in paragraph 35a through e.

(b) Lever switch S3 is similar to lever switch S2, and is connected to binding posts T and R of PR-2. It establishes the same circuits to these binding posts as lever switch S2 does to the binding posts T and R of PR-1 (subpar. (a) above).

(c) Push switch S4 (MEGOHMS) consists of two sets of contacts. Each set comprises one center movable contact and two lateral stationary contacts.

1. In the normal position, push switch S4 connects part of the output of amplifier V2 (fig. 20) to the variable arm of the slide-wire potentiometer R22. This circuit is established through the lower stationary contact of the upper set of contacts, the upper center contact, and through the corresponding contacts of push switches S5 and S6.

2. When push switch S4 is depressed (closed), the negative side of Battery BA-59 is connected through terminals B of plug P1 and receptacle J1, resistor R18, upper stationary contact and upper center contact of push switch S4 to the variable arm of the slide-wire potentiometer R22 through the top set of contacts of push switches S5 and S6.

3. In the normal position, push switch S4 also closes the circuit from terminal 5 of section 1 of SELECTOR switch S7, terminals 7 and 10 of section 2 of S7 through calibrating capacitor C10, top stationary contact of the lower set of contacts of push switch S4, lower center contact of push switch S4, and the corresponding sets of contacts of push

switches S5 and S6 to terminal 8 of section 1 of SELECTOR switch S7.

4. In the closed position, the lower set of contacts of push switch S4 establishes the same circuit as described in subparagraph (c)3 above, except that resistor R19 is substituted for capacitor C10.

(d) Push switch S5 (OHMS X100) is identical in construction to push switch S4 (subpar. (c)).

1. The upper set of three contacts of push switch S5 establishes the same circuits as the upper set of contacts of push switch S4 (subpar. (c)1 and 2).

2. In the normal position, the lower set of three contacts of push switch S5 establishes the same circuit as the lower set of contacts of push switch S4 (subpar. (c)3).

3. In the closed position, the bottom set of contacts connects resistor R20 in place of R19 in the circuit described in subparagraph (c)4 above.

(e) Push switch S6 (OHMS) is identical in construction to push switch S4 (subpar. (c)).

1. The upper set of three contacts of push switch S6 establishes the same circuits as the upper set of contacts of push switch S4 (subpar. (c)1 and 2).

2. In the normal position, the lower set of three contacts of push switch S6 establishes the same circuit as the lower set of contacts of push switch S4 (subpar. (c)3).

3. In the closed position, the bottom set of contacts connects resistor R21 in place of R19 in the circuit described in subparagraph (c)4 above.

(8) The indications of the bridge, when the OPENS push key is depressed and the SELECTOR switch is set at T-R, are read from scale A on the dial. These readings are then transferred to the appropriate curve in the lid of the carrying case and the equivalent parallel capacitance of the unknown, or the distance to the open fault, is determined from the curve. More specific instructions may be found in paragraph 17e.

CHAPTER 5

FIELD MAINTENANCE INSTRUCTIONS

Section I. TROUBLE SHOOTING AT FIELD MAINTENANCE LEVEL

36. Test Equipment Required for Trouble Shooting, and Testing Power Supply

The equipment listed below is required for trouble shooting and testing power supply.

Tool or test equipment	Stock No.	Use
Tube Tester I-177	3F5700-177	For testing tubes
Multimeter TS-352/U	3F4325-352	General purpose multimeter
Test Set ZM-4B/U	3F3936-4	Internal battery

37. Trouble Shooting Procedure

a. Unnecessary disassembly of the test set may cause additional trouble instead of correcting existing trouble. Before attempting to trouble shoot the set, make sure that faulty operation is not due to incorrect usage or to causes outside of the set.

b. Check the panel controls to make sure they are positioned according to the instructions which cover the specific test being made. In many cases, failure to obtain a bridge balance is due to the wrong position of one or more of the panel controls.

c. Check connections between the bridge binding posts and the outside circuit. Faulty indications may be due to poor outside connections.

d. Check the test leads and the patch cord to make sure that the wires are not broken or the insulation is not damaged. Replace new leads for those found to be damaged.

e. Check battery voltages and connections to the batteries. Failure to balance the bridge may be due to weak or dead batteries, or to poor connections.

Note. The operator must acquire a knowledge of abnormal outside conditions which result in unsatisfactory test set operation.

38. Trouble Shooting Chart

Trouble	Possible cause	Corrective action
Galvanometer fails to deflect with SELECTOR switch S7 at T-R, T-G, R-G position, and with OHMS push switch depressed.	Batteries BA-59 disconnected or run down.	Reconnect or replace.
	Loose connection in battery circuit.	Make repairs.
	OHMS push switch not making contact.	Clean or readjust.
	Defective galvanometer.	Replace.
	Shorted varistor CR2.	Replace.
Galvanometer fails to deflect with SELECTOR switch S7 at T-R and with OPENS push switch depressed.	Battery BA-15-A disconnected or run down.	Reconnect or replace.
	Batteries BA-59 disconnected or run down.	Reconnect or replace.
	Tube V1 or V2 defective.	Replace.
	OPENS switch S1 not making contact.	Clean and readjust.
	Defective galvanometer.	Replace.
	Shorted varistor CR1 or CR2.	Replace.
No plate voltage on tube V1.	Resistor R7 open.	Check wiring, if not open replace resistor.
No plate voltage on tube V2.	Resistor R10 open.	Check wiring, if not open replace resistor.
No screen voltage on tube V1.	Resistor R6 open.	Check wiring, if not open replace resistor.

38. Trouble Shooting Chart (contd)

Trouble	Possible cause	Corrective action
No screen voltage on tube V2.	Plus side of the BA-59 battery may be open.	Check wiring, if not open check battery.
Conductor resistance readings not stable.	Defective CR2 varistor or dirty switch contacts.	Replace varistor. Clean switch contacts.
	BA-59 batteries failing.	Replace if needed.
	Poor contact on R22 slide-wire.	Clean and adjust.
Capacitance reading not stable.	Defective varistor CR1 or CR2.	Replace.
	Defective oscillator tube V1.	Replace.
	Defective amplifier tube V2.	Replace.
	OPENS switch S1 contacts not making.	Clean and adjust.
	Batteries BA-59 weak.	Replace.
	Battery BA-15-A weak.	Replace.
	Slide-wire R22 not making contact.	Clean and adjust.
Inaccurate resistance measurements.	Deterioration of resistors R19, R20, R21.	Test and replace if necessary.
	Deterioration of slide-wire R22.	Test and replace if necessary.
	Loose connections or corroded contacts.	Inspect, clean and adjust.

Trouble	Possible cause	Corrective action
Inaccurate capacitance measurements.	Defective C10 capacitor.	Test and replace.
	Open V1 oscillator tube circuit.	Check oscillator tube V1 and wiring of oscillator circuit.
	Setting on resistor R14 off.	Measure and reset R14 resistor.
	Loose connections or corroded contacts.	Check and clean or resolder all contacts and connections.

39. Continuity Tests

Check the five test leads and the cord at weekly intervals for opens or poor connections. Use a Multimeter TS-352/U.

a. The Multimeter TS-352/U has an indicating meter mounted in the center of the panel near the top. Set the FUNCTION SWITCH on OHMS and insert CORD CX-939/U in the two jacks marked OHMS and set the RATIO SWITCH (bottom right-hand corner) on RX-1, then set the needle on zero by turning the OHMS ZERO ADJ. switch. This should be repeated each time the ratio is changed, in order to insure correct readings. Cord CX-939/U is supplied with the multimeter.

b. With the switches in the same position as in subparagraph a above, remove Cord CX-939/U from the OHMS jacks and replace it with one of the cords to be tested for continuity. The meter should indicate a short circuit. If the needle fails to swing across the scale, an open is indicated. While testing the lead, move it about, keeping the pins firmly in the jacks. If the needle jumps or flickers, it indicates a poor connection. Such faults are likely to occur at the point where the cord tinsel enters the tip. The cords supplied with Test Set TS-27B/TSM have a pin tip on one end and a clip on the other end, making it necessary to use two cords clipped together, when performing the above test.

c. If an open is suspected in the test set, make a point-to-point continuity test of the wiring, as outlined above, but use the cords furnished with Multimeter TS-352/U. Be sure Test Set TS-27B/TSM batteries are disconnected and that no resistors, capacitors, or open switches are in series with the wiring being checked for the open. Refer to figures 20 and 21.

40. Resistance and Voltage Tests

The various resistors may be checked while the chassis is removed from the case. This should be done every six months or whenever some fault in the operation of the set indicates the need for such a test.

a. Use the multimeter with the FUNCTION switch set for OHMS and the other switch set for whatever ratio is needed for the particular circuit component being measured. These resistance values for each component may be obtained from the schematic diagram, figure 20, or the wiring diagram, figure 21. Table II, furnishes a terminal-to-terminal measurement of the oscillator circuit. Figure 28 explains the resistor color and letter code. Carefully follow the directions supplied with the multimeter. Be sure that nothing except the test prods, or clips, is in contact with resistor terminals while testing them. Such contacts may cause the multimeter to give a false reading, especially when high resistances are tested. Be sure that all batteries in the test set are disconnected.

b. Standard resistors R21 and R20 are precision units accurate to 100 and 10,000 ohms, respectively, within ±.1 percent. Resistor R19 is one megohm ±1.0 percent. These three standards cannot be checked accurately by means of ordinary ohmmeters. To check these standards, use Test Set ZM-4B/U or another Test Set TS-27B/TSM, known to be in good condition. Indications for the 100- and 10,000-ohm units should be within ±2 percent; for the megohm unit, within ±5 percent. Failure to meet these accuracies means that either the standards in the bridge or its slide-wire is at fault, or the contact resistance at the switch and keys may be excessive. Locate the actual fault by the process of elimination.

c. Voltage tests are made with the batteries connected and with the appropriate switches closed. To check plate, screen, and filament voltages, turn SELECTOR switch S7 to T-R position and keep OPENS push key S1 depressed. Take voltage readings with a multimeter having its FUNCTION switch turned to the VOLTS position. Be sure to use a voltmeter range high enough to permit the meter to measure up to 90 volts when checking plate, screen, or the 45-volt battery voltages. Use the lowest range when checking filament voltages. Check readings with those given in table III only when a VTVM (vacuum tube voltmeter) is used. Readings materially below normal indicate loose contacts, resistor deterioration or the need for battery replacements. Lack of voltage indicates an open or a dead battery.

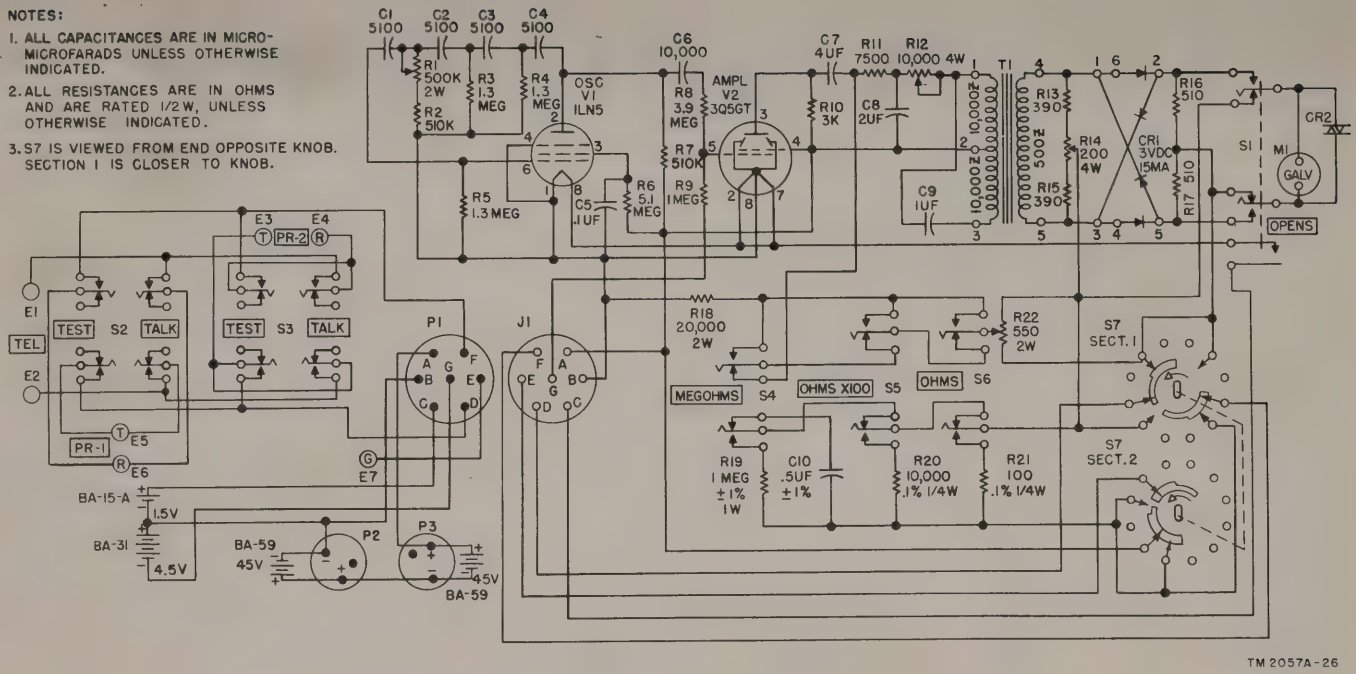

Figure 20. Test Set TS-27B/TSM, schematic diagram.

d. When testing the plate voltage of tube V2, difficulty may be experienced in taking a reading because of the vibration caused by the 20-cycle alternating current present in this circuit. Observe the average deflection.

TABLE II

RESISTANCE READINGS

Conditions: Remove V1 and V2.

Disconnect plug P1 from **socket J1**.

Measure				Resistance
From		To		
Item	Terminal	Item	Terminal	(ohms)
XV1	1	XV1	2	infinity
XV1	1	XV1	3	infinity
XV1	1	XV1	4	infinity
XV1	1	XV1	6	1.3 meg
XV1	2	XV1	3	5.6 meg
XV1	2	XV2	3	513,000
XV2	2	XV2	5	infinity
XV2	2	XV2	7	0
XV2	3	XV2	4	3,000
XV2	4	XV2	8	infinity
T1	1	T1	3	1,500
T1	1	T1	4	infinity
T1	4	T1	5	30

TABLE III

VOLTAGE READINGS

Conditions: All voltages are dc.

All voltages are measured with respect to negative side of B battery (terminal - on P2).

Voltages are measured with VTVM.

Voltages between - of P2 and + on P3 to be 92 volts with S1 depressed.

Close S1 for all measurements.

Item	Terminal	Voltage
XV1	1	0
	2	86
	3	56
	4	0
	5	0
	6	-0.4
	7	0
	8	1.5
XV2	1	0
	2	1.5
	3	89.5
	4	92
	5	-4.4
	6	0
	7	1.5
	8	0
T1	1	90.5
	2	92
	3	91.5
	4	92
	5	92

Section II. REPAIR

CAUTION: Be sure to final test the test set after every disassembly or repair (pars. 49, 50, and 51) to insure that its accuracy has not been impaired by adjustment or replacements.

41. Removal of Chassis from Case

a. Loosen the four thumbscrews in the corners of the instrument panel, and lift the bridge from the case by means of the two handles on the panel. Sufficient slack is provided in the cable to allow the chassis to rest on the top edges of the case.

b. To separate the chassis from the case, disconnect P1 from receptacle J1 on the chassis. To do this, first unscrew the ring at the base of the plug, then pull the plug away from the receptacle.

42. Removal and Replacement of Batteries

a. REMOVAL.

(1) Loosen the thumbscrew (fig. 22), and remove the battery compartment cover from the case.

(2) Lift Batteries BA-59 from the battery compartment, and remove plugs P2 and P3 from the batteries.

(3) Lift Battery BA-15-A from the battery compartment, loosen battery terminal nuts, and remove wires from battery.

(4) Lift Battery BA-31 from the battery compartment, loosen battery terminal nuts, and remove wires from the battery.

b. REPLACEMENT.

(1) Secure wires to Battery BA-31 terminals by means of the terminal nuts. Connect black wire to the plus terminal, and brown wire to the minus terminal. Check the wiring with the wiring diagram shown in figure 21. Insert the battery in an upright position into the lower left-hand corner of the battery compartment under the battery clip (fig. 22).

(2) Secure wires to Battery BA-15-A terminals by means of the two terminal nuts. Connect the brown wire to the plus terminal, and the red wire to the minus terminal. Check the wiring with the wiring diagram shown in figure 21. Insert the battery flat against the bottom of the battery compartment between the two

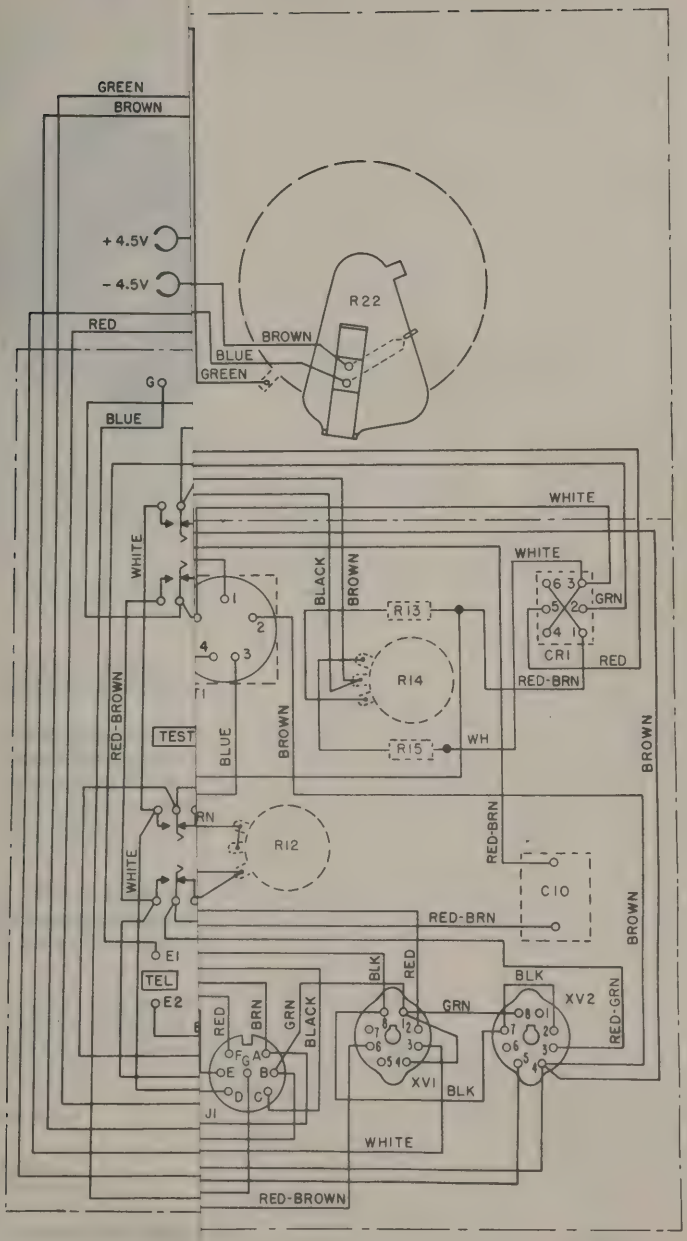

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Figure 21. Test

Section II. REPAIR

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b. REPLACEMENT.

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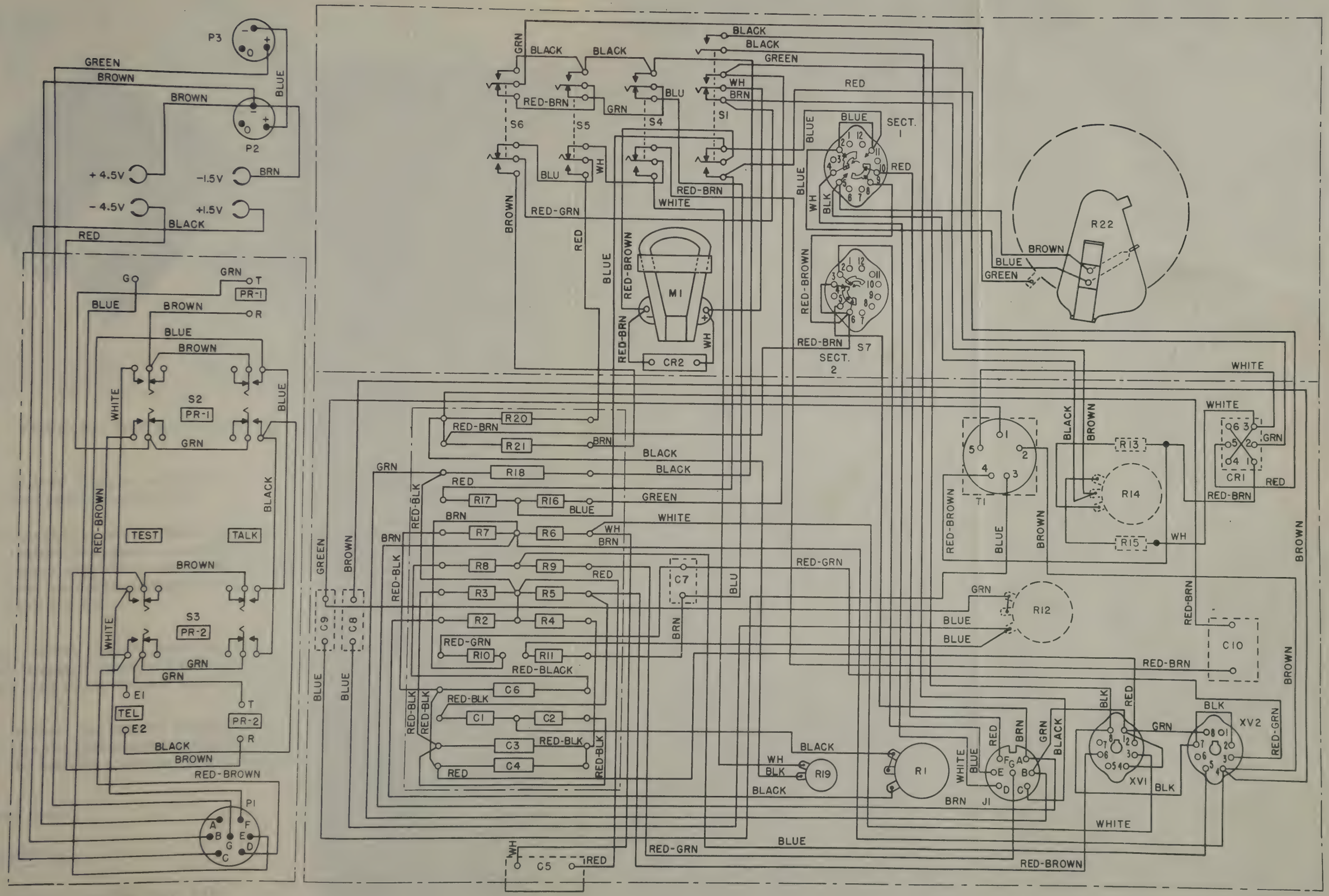

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Figure 21. Test Set TS-27B/TSM, wiring diagram

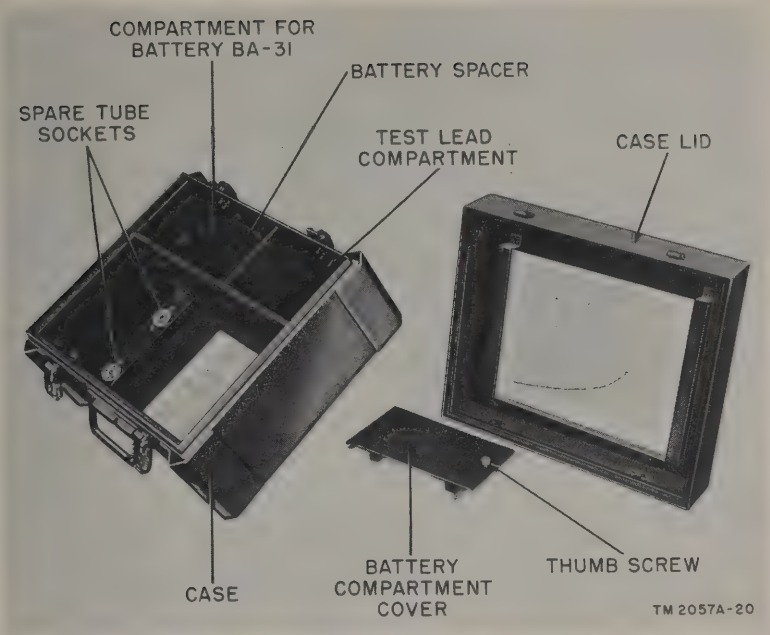


Figure 22. Test Set TS-27B/TSM, case components.

battery flanges so that the battery terminals face toward the test lead compartment.

(3) Insert plug P2 in Battery BA-59 terminals. Place the battery inside the battery compartment flat on top of Battery BA-15-A. Insert plug P3 in the second Battery BA-59, and place the battery inside the battery compartment flat on top of the first Battery BA-59.

Note. When 45-volt batteries are used, which are slightly wider than the standard Battery BA-59, remove the battery spacer (fig. 22) from the side of the battery compartment.

(4) Replace the battery compartment cover by fitting the end opposite the thumscrew to the flange of the test set case. Secure the battery cover to the case by means of the thumbscrew.

43. Control Panel

a. REMOVAL.

(1) Remove chassis (par. 41).

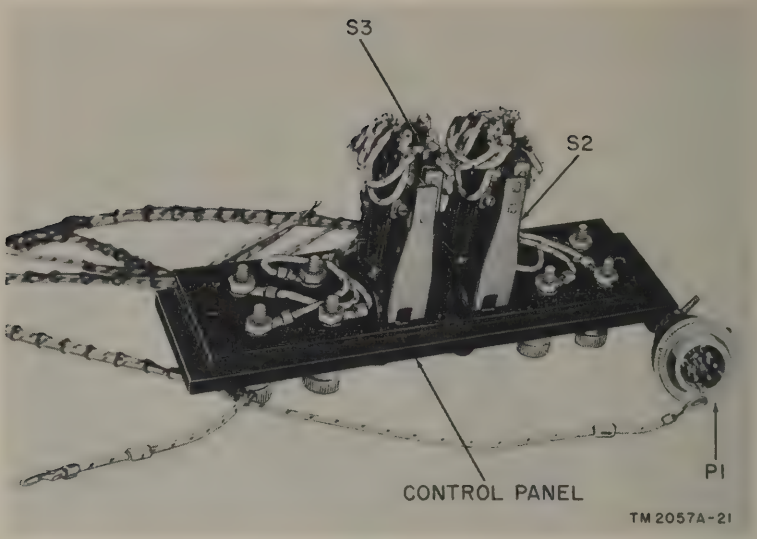


Figure 23. Test Set TS-27B/TSM, bottom view of control panel.

(2) Remove two flathead screws from upper and lower end of control panel, and lift panel (fig. 23) from case.

b. REPLACEMENT.

(1) Place the control panel on the case so that top of the panel binding post G is closest to the battery compartment.

(2) Secure the panel to the case by means of two flathead screws.

(3) Replace chassis (par. 41).

CAUTION: With the chassis and the control panel removed from the case, the electrical components of the test set are sufficiently accessible to perform all necessary tests in order to determine and locate faulty components. Further disassembly of the unit is not recommended, unless such disassembly is made necessary by the need to replace defective items. For procedures to be followed during such replacement refer to the instructions given in paragraph 45. Refer to paragraphs 37 through 40 for component tests.

44. Replacement of Tubes

Spare tubes for the test set are provided in the bottom of the compartment underneath the control panel (fig. 20). To gain access to the tubes, remove the set from the case (par. 41).

a. One tube V1 (1LN5) and one tube V2 (3Q5GT) are required for the operation of the test set. The former tube has a special locking arrangement for holding it securely in the socket and assuring good contact. This tube is known as a loctal-type tube. It should not be removed with a direct upward pull as in the case of tube V2 (3Q5GT). Remove tube V1 (1LN5) by applying a gentle off-side pressure. This releases the socket lock and the tube is then readily removed. Be careful not to apply pressure in a side-wise direction after the lock has been released; this may cause the tube prongs to bend. If a loctal tube lifter is available use this, prying the tube carefully from the socket and guiding it at the same time with the free hand.

b. After removal of the tubes, test them with Tube Tester I-177-A, or equivalent. It will be necessary to use a loctal adapter to test tube 1LN5 on some tube checkers. If the needle swings to the green section of the scale, the tube is good. If it fails to reach the green section, the tube should be replaced. Check the tubes for shorted elements and leakage. Return the good tubes to their original sockets. Since one tube is an octal type and the other is a loctal, it is impossible to interchange them accidentally. Replace defective tubes with the tubes from the spare compartment, and order replacement as soon as possible.

45. Replacement of Components

a. GENERAL.

(1) Faulty components may be removed from the test set and replaced with new ones without undue difficulty. Special tools are not needed. Whenever a part is to be replaced, first remove the set from the case and disconnect plug P1 from receptacle J1 (par. 41). Recommended methods for replacing new parts are given below.

(2) When reassembling components, make connections to each part as that part is being reassembled, and check all connections with the wiring diagram of figure 21. Make sure that color coding of each wire is the same as that shown in figure 21. Complete all soldering as described in TB SIG 222. Remove loose solder to prevent short circuits. Make sure bare wires or terminals do not touch chassis or other structural parts. Calibrate the test set as instructed in paragraphs 46 through 48.

b. SLIDE-WIRE POTENTIOMETER R22. Release the instrument panel by taking out the flathead screws in each of the four corners. Turn the panel over (fig. 24) and rest it carefully on a suitable support. Loosen the small hexagonal nut (fig. 25) on the end of the shaft nearest the drum. Remove the dial drum carefully so as not to damage the contact arm which bears on the slide-wire. A certain amount of pressure may be necessary to do this. Remove the pin from the knob shaft and then lift out the knob. Solder the leads to the new slide-wire potentiometer R22; check connections with the wiring diagram of figure 21.

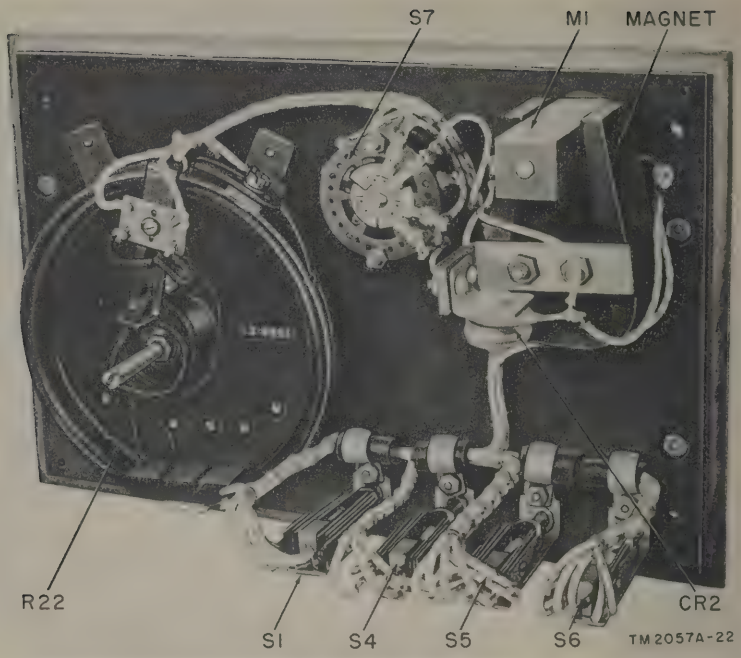


Figure 24. Test Set TS-27B/TSM, bottom view of instrument panel.

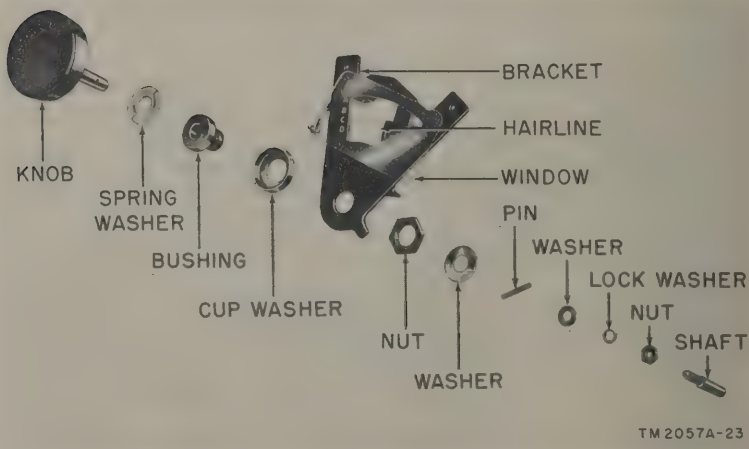


Figure 25. Test Set TS-27B/TSM, exploded view of slide-wire potentiometer (R22) knob and mounting bracket.

CAUTION: Handle the slide-wire potentiometer carefully to avoid damaging the winding. Do not touch the winding with bare hands or fingers, since this may throw the potentiometer out of calibration. Slight nicks in the wire may also cause faulty indications, and are therefore to be avoided. Reassemble the new slide-wire potentiometer to the instrument panel by reversing the removal procedures given above. Make certain the leads from the slide-wire are wrapped around the shaft properly (fig. 24) to allow for the slack needed by the turning of the drum.

c. SELECTOR SWITCH S7. Remove the knob after loosening the set-screw, then loosen and remove the hexagonal nut which holds the selector switch shaft bushing to the instrument panel. Tag all leads and unsolder from the selector switch terminals. Solder leads to new selector switch, and check connections with the wiring diagram of figure 21. Mount the new selector switch on the instrument panel by reversing removal procedures given above.

d. GALVANOMETER M1. Remove the two fillister-head screws from the galvanometer system (front of panel) and lift out the galvanometer. These screws make the circuit connections to the meter so that on their removal the meter is out of the circuit and free for removal. Place new meter in position on panel and secure with two fillister-head screws. Check the continuity of the galvanometer connections.

e. PUSH SWITCHES S1, S4, S5, AND S6. Tag and disconnect wires from push switch terminals. Remove the flathead mounting screw from top of panel, and separate the defective push switch from the panel. Insert the new push switch through the hole in the panel, and secure with a flathead screw. Make connections to the push switch terminals, and check with the wiring diagram of figure 21.

f. LEVER SWITCHES S2 AND S3. Remove the control panel, and turn it face down on a suitable working surface (fig. 23). Disconnect the leads from the terminals. Remove four mounting screws from the defective lever switch, and remove the lever switch from the control panel. Mount the new lever switch in place by reversing the removal procedures.

g. BINDING POSTS. Remove control panel, and turn it face down on a suitable working surface (fig. 23). Disconnect wire from defective binding post. Remove mounting nut from under side of panel, and remove the binding post from the panel. Mount new binding post in place by reversing removal procedures.

h. TRANSFORMER T1. Remove the chassis from the case (par. 41), and remove the instrument panel from the chassis (subpar. b above). Disconnect the lead from the transformer terminals, on the bottom of the chassis (fig. 26). Loosen the four mounting nuts on the bottom of

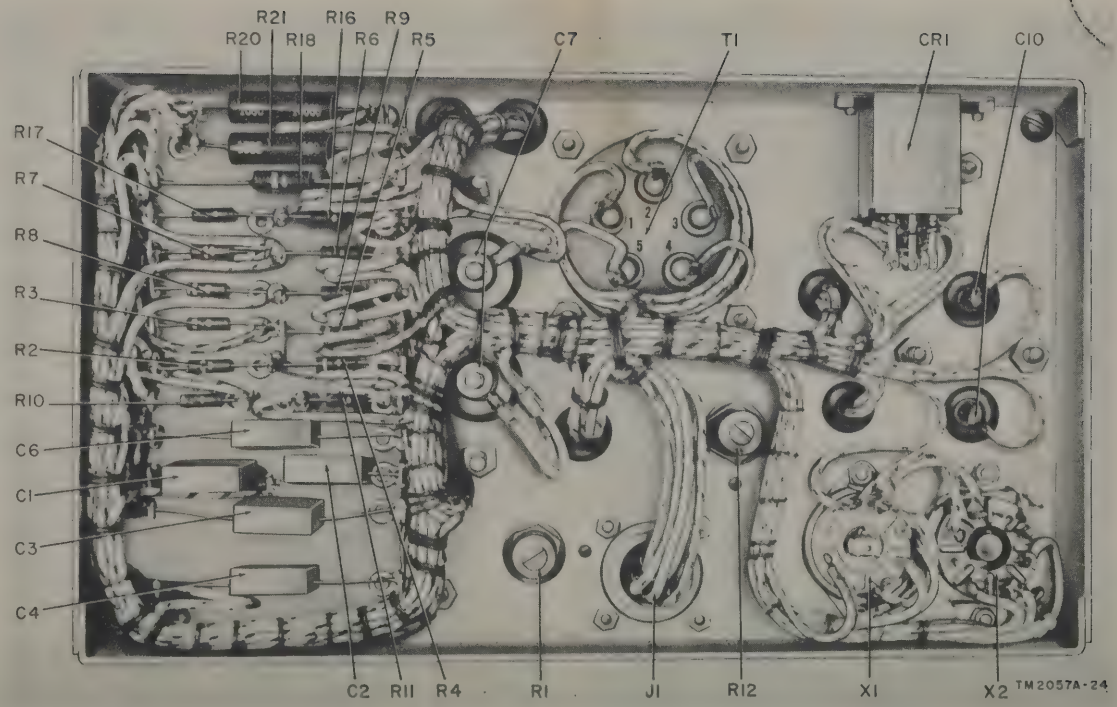


Figure 26. Test Set TS-27B/TSM, bottom view of chassis.

the chassis, and remove the four mounting screws from the top of the chassis (fig. 27). Install the new transformer by reversing the removal procedures.

i. CAPACITOR C7. Remove the chassis from the case (par. 41). Remove the instrument panel from the chassis (subpar. b above). Disconnect the leads from the capacitor terminals on the bottom of the chassis (fig. 26). Loosen and remove the two mounting nuts on the bottom of the chassis, lift the mounting brackets from the top of the chassis, and remove the capacitor. Install the new capacitor by reversing the removal procedures.

j. OTHER PARTS. Parts, such as resistors, varistors, capacitors, receptacles, etc., are readily replaced and require no special instructions. In some instances, for example in the case of variable resistors, one-hole mounting is used and it is necessary merely to loosen the hexagonal nut to remove the component. In other cases the part may be held in place by mounting screws and nuts. An examination of the part to be replaced will show the method to be followed in making the change. Figures 26 and 27 show the bottom and top of the chassis respectively. After installing new parts, check the circuit with the wiring diagram of figure 21.

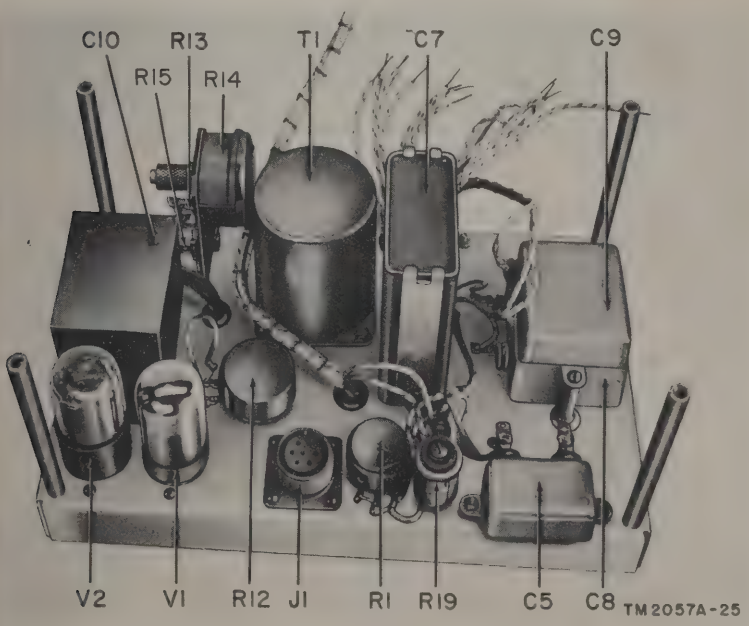


Figure 27. Test Set TS-27B/TSM, top view of chassis.

Section III. CALIBRATION

46. Preliminary Procedure

a. Release the four screws at the corners of the panel, and lift out the panel and chassis assembly of the set. Rest the chassis on a pair of supports so that a small screw driver may be used to reach the slots in the variable resistors mounted on the chassis. This usually requires that the lid be completely removed from the rear hinges and the case set on its side, with the battery compartment uppermost.

b. Check the tubes and the batteries and change any equipment that does not measure up to the required standard.

c. Make certain that the galvanometer indicates zero when none of the push switches is depressed. If this is not the case, adjust the galvanometer to zero by releasing the clamping screw on the knob, turning it until zero is indicated, and then tightening the screw again. Be careful not to tighten the clamping screw too much or the knob may crack.

47. D-c Calibration

a. Connect a resistor, known to be accurate, to terminals T and R of PR-1 of the set, throw lever switch PR-1 to TEST, set the selector switch at T-R, and depress the OHMS push switch S6 or OHM X100 push switch S5. Release the galvanometer movement and turn the dial slowly until the galvanometer indicates zero. If the resistance indicated on scale C checks the value of the known resistor under test, the contactor on the slide-wire need not be disturbed.

b. If the reading on scale C differs by more than two percent from the known value of the resistor under test, release the screw which clamps the slide-wire contactor to the hairline bracket (fig. 24), and carefully shift the position of the contactor until the galvanometer indicates zero when the proper push switch (OHMS or OHM X100) is depressed. Then tighten the clamping screw, being very careful not to change the position of the contactor. Depress the proper push switch again and check the clamped position of the contactor. Disconnect the known resistor from binding posts T-R of PR-1.

48. A-c Calibration

a. With nothing connected to the T and R binding posts of the set and both PR lever switches in the upright or normal position, set the SELECTOR switch S7 to T-R and depress the OPENS push switch S1. The galvanometer should deflect. Carefully turn the slide-wire knob in a clockwise direction, as far as it will go. It should come to a stop at a point where the hairline will indicate zero on scale A.

b. With the galvanometer zero properly adjusted, and the slide-wire set with the zero on scale A at the hairline, depress the OPENS push switch S1. The galvanometer should read exactly zero. If it does not, release the locking device on variable resistor R14, and reset that resistor until the galvanometer does indicate zero. This should be done very carefully, because any error in this setting will be carried into all a-c measurements. Tighten the locking device on R14 and repeat the test to check the final setting. With the resistor R14 shaft locked and the slide-wire R22 set as described above, the galvanometer should read exactly zero.

c. Connect a good paper or mica capacitor, of a value equal to one listed in table IV, to binding posts T and R of PR-1 and turn lever switch PR-1 to TEST. With the SELECTOR switch S7 set at T-R, depress the OPENS push switch S1 and turn the slide-wire R22 knob until the galvanometer indicates zero. Do not disturb this setting of the slide-wire R22. Next, connect the corresponding resistor listed in table V to binding posts T and R of PR-2, and throw lever switch PR-2 to TEST. This parallels the capacitor and the resistor. Depress the OPENS push switch S1 once more. The galvanometer should read zero. If it does not, release the locking device on variable resistor R12 and vary that resistor until the galvanometer does read zero. When this is done, lock the resistor R12 shaft and repeat the test to make certain that the locking process has not shifted the setting of R12. The set is now completely calibrated.

d. Occasionally, it may be found that the limit of adjustment of R12 is reached before the galvanometer returns to zero, when the resistor is shunted across the capacitor as described in subparagraph c above. When this is the case, release variable resistor R1 and turn its shaft counterclockwise (thereby increasing the frequency of the oscillator) until the galvanometer needle indicates zero, then lock the resistor R1 shaft and repeat the test, as in subparagraph c above, to make sure that both R1 and R12 are set properly.

e. Variable resistor R1 controls the frequency of the oscillator. This frequency is affected considerably by the selection of the oscillator tube, V1. When that tube is such that the frequency of the set is lowered too much, R12 cannot shift sufficiently the phase of the voltage output of transformer T1, and the set cannot be adjusted. Under such conditions, the frequency of the oscillator must be reset by varying R1; a higher resistance in this variable resistor yields a lower frequency, and vice versa.

TABLE IV

PARALLEL R-C COMBINATIONS FOR CALIBRATING TS-27B/TSM

Resistance (ohms)	Capacitance (uf)
15,000	2
30,000	1
60,000	.5
300,000	.1

f. It may be noticed that the products of corresponding values of R and C listed in table IV, all equal 30,000, when C is expressed in microfarads. These parallel combinations all yield a power-factor of approximately 25 percent. If the capacitor which is available is not one listed in table IV, the corresponding resistor may be calculated by dividing 30,000 by the capacitance expressed in microfarads. For example, if the capacitor available is a 1.5-uf unit, the proper shunting resistor is

$$\frac{30000}{1.5} = 20{,}000 \text{ ohms.}$$

The capacitors used for calibrating the TS-27B/TSM should be good quality paper or mica units. Electrolytic capacitors should never be used, because such capacitors have leakages which are too large to be neglected. Even capacitors of good quality but of unknown capacitance may be used to calibrate TS-27B/TSM. Such a capacitor is connected to the input of the set, as described in subparagraph c above. When the set is balanced, the reading on scale A is transferred to the capacitance calibration curve, on the chart, in the lid of the set. From this curve, the value of the capacitance may be determined. The corresponding value of the necessary shunting resistance is calculated by dividing 30,000 by the capacitance in microfarads. Remeasure the value of the unshunted, unknown, capacitor, used for calibration, after the set is calibrated. The values indicated before and after the adjustments required for calibration is made, should check very closely. If they do not, repeat successive calibrations and measurements until the indicated values of the unknown capacitor are always the same.

$R \times C = 2{,}000$ if R and C are in series.

Section IV. FINAL TESTING

49. Galvanometer

As soon as the galvanometer is unclamped make sure that the needle swings freely. If it fails to do this, the instrument probably has been damaged, and it will be necessary to replace it.

50. D-c Circuits

To check the operation of the d-c circuits in the test set, short-circuit binding posts T and R of PR-1, throw lever switch PR-1 (S2) to the TEST position, and set the selector switch S7 to the T-R position. Depress the OHMS push switch (S1). The galvanometer needle should read zero when the slide-wire dial is set at the zero point on scale D. It should deflect to the right at all other positions of the dial. Remove the short circuit and depress the OHMS push switch (S6). The galvanometer needle should read zero when the slide-wire dial is set at zero on the scale A and should deflect to the left at all other positions of the dial. This test should also be possible with the OHMS X100 push switch (S5) or the MEGOHMS push switch (S4) depressed. This entire test should be repeated with lever switch PR-2 (S3) thrown to the TEST po-

sition, using binding posts T and R of PR-2 instead of posts T and R of PR-1. If the galvanometer fails to deflect, this may be due to the fact that the 45 volt batteries are disconnected or run down or because of a loose connection in the battery circuit. Make sure that the battery plugs P2 and P3 are inserted in the batteries properly. Replace the batteries if necessary. Restore all switches to their normal positions.

51. A-c Circuit

To test the operation of the a-c circuit, short-circuit binding posts T and R of PR-1 (S2), throw lever switch PR-1 (S2) to the TEST position, and set the SELECTOR switch (S7) to T-R. Depress the OPENS push switch (S1). The galvanometer should read zero when the dial is set at 100 on scale A. It should deflect to the right at all other positions of the slide-wire dial. Remove the short circuit and restore PR-1 (S2) to its normal position. When the slide-wire dial is set at zero on the OPENS scale, the galvanometer needle should read zero when the OPENS push switch (S1) is depressed, and should deflect to the left at all other times. If the galvanometer fails to deflect, check Battery BA-15-A and Batteries BA-59. Check both tubes and take plate and screen voltage readings to determine if trouble has developed in any portion of the oscillator circuit. Voltage readings should check with those shown in table III when taken with a VTVM. When checking tubes, note whether the prongs are bent or coated with an insulating film. This latter trouble may be remedied by cleaning the prongs with fine sandpaper or crocus cloth.

CHAPTER 6

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

52. Removing Test Set TS-27B/TSM from Service

a. Remove batteries from battery compartment.

b. Clean corrosion from wire ends and dirt accumulation from the battery compartment. Use a clean cloth moistened with solvent (SD).

c. Fold the test leads and the patch cord, and place them in the test lead compartment. Fill up the compartment with paper or other material which will prevent excessive movement of the leads during transit.

d. Make sure that the galvanometer movement is clamped by moving the CLAMP button away from the galvanometer scale.

53. Packing the Test Set for Storage

Repack the test set in the original package if the packaging is available (fig. 2). If the original packaging is not available, pack the unit carefully in a wooden box of appropriate size with corrugated paper cushioning at least 1 inch thick on all sides of the test set case. Nail a wooden box cover securely in place over the open top of the box.

54. Packing for Shipment

If the test set is to be transported or shipped, it must be repacked. Repack it as closely as possible in accordance with the packaging diagram in figure 2.

Section II. DEMOLITION TO PREVENT ENEMY USE

55. Methods of Demolition

a. SMASH. Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

b. CUT. Use axes, handaxes, machetes.

c. BURN. Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

d. EXPLODE. Use firearms, grenades, TNT.

e. DISPOSE. Bury in slit trenches, fox holes, other holes. Throw into streams. Scatter.

Note. Use anything immediately available for destruction of this equipment.

56. Destruction of Components

When ordered by your commander, destroy all equipment to prevent its being used or salvaged by the enemy.

a. Smash (par. 55a) the case, panels, meter.

b. Cut (par. 55b) all wiring in electrical circuits.

c. Burn (par. 55c) all instruction books, charts, etc.

d. Bury or scatter (par. 55e) all remaining parts of the equipment.

e. DESTROY EVERYTHING.

APPENDIX I

REFERENCES

Note. For availability of items listed, check SR 310-20-3, SR 310-20-4, and SR 310-20-5. Check Department of the Army Supply Catalog SIG 1 for Signal Corps Supply Catalog pamphlets.

1. Army Regulations

AR 380-5	Military Security (Safeguarding Military Information).
AR 750-5	Maintenance of Supplies and Equipment (Maintenance Responsibilities and Shop Operation).

2. Supply Bulletins

SB 11-6	Dry Battery Supply Data.
SB 11-47	Preparation and Submission of Requisitions for Signal Corps Supplies.
SB 11-100	Serviceability Standards for Signal Equipment in Hands of Troops.

3. Auxiliary Equipment and Test Equipment

TM 11-300	Frequency Meter Sets SCR-211-A, B, C, D, E, F, J, K, L, M, N, O, P, Q, R, T, AA, AC, AE, AF, AG, AH, AJ, AK, AL.
TM 11-307	Signal Generators I-72-G, H, J, K, and L.
TM 11-2019	Test Set I-49.

TM 11-2613	Voltohmmeter I-166.
TM 11-2626	Test Unit I-176, I-176-A, and I-176-B.
TM 11-2627	Tube Tester I-177 and I-177-A.
TM 11-5527	Multimeter TS-352/U.

4. Painting, Preserving, and Lubrication

TB SIG 13	Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 23	Rustproofing of Engines.
TB SIG 69	Lubrication of Ground Signal Equipment.
TM 9-2851	Painting Instructions for Field Use.

5. Camouflage, Decontamination, and Demolition

FM 5-20	Camouflage, Basic Principles.
FM 5-25	Explosives and Demolitions.
TM 3-220	Decontamination.

6. Other Publications

FM 24-5	Signal Communications.
FM 24-20	Field Wire Technique.
FM 72-20	Jungle Warfare.
SR 700-45-5	Unsatisfactory Equipment Report (Reports Control Symbol CSGLD-247).
SR 745-45-5 NAV DEPT SERIAL 85P00 AFR 71-4	Report of Damaged or Improper Shipment (Reports Control Symbols CSGLD-66 (Army), SandA-70-6 (Navy), and AF-MC-U2 (Air Force)).
TB SIG 25	Preventive Maintenance of Power Cords.
TB SIG 66	Winter Maintenance of Signal Equipment.
TB SIG 72	Tropical Maintenance of Ground Signal Equipment.
TB SIG 75	Desert Maintenance of Ground Signal Equipment.

TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TB SIG 219	Operation of Signal Equipment at Low Temperatures.
TB SIG 223	Field Expedients for Wire and Radio.
TM 11-369	Spiral-Four Cable.
TM 11-371	Cable Assembly CC-345 (5 pair).
TM 11-372	Cable Splicing.
TM 11-430	Batteries for Signal Communication. (Except those pertaining to Aircraft).
TM 11-462	Signal Corps Tactical Communication Reference Data.
TM 11-475	Long Distance Telephone Transmission.
TM 11-661	Electrical Fundamentals (Direct Current).
TM 11-676	Grounding Procedure and Protective Devices.
TM 11-681	Electrical Fundamentals (Alternating Currents).
TM 11-757	Principles of Fault Location.
TM 11-2050	Test Set I-48B.
TM 11-2063	Test Board BD-101.
TM 11-2261	Telephone Outside Plant Engineering.
TM 11-2262	Open Wire Pole Line Construction and Maintenance.
TM 11-2263	Lead-Covered Cable Construction and Maintenance.

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Note. The following is an identification table of parts for Test Set TS-27B/TSM (Sig C stock No. 3F4325-27). The fact that a part is listed in this table is not sufficient basis for requisitioning the item. Requisitions must cite an authorized basis, such as a specific T/O&E, SIG 7 & 8, SIG 7-8-10, T/A, list of allowances of expendable material, or another authorized supply basis.

For an index of available supply catalogs in the Signal portion of the Department of the Army Supply Catalog, see the latest issue of SIG 1, Introduction and Index.

Identification Table of Parts (contd)

Ref symbol or fig. No.	Name of part and description	Function of part	Signal Corps stock No.
Fig. 3	BOLT, thumb: zinc-coated and chromated; slot-drive; cone point; 7/8" nom lg.	Secures capacitance-resistance bridge to case.	6L17108-21P
Fig. 3	BRIDGE, capacitance-resistance: .1 uf to 3 uf of equivalent parallel capacitance, having a dissipation factor not exceeding .265 at a frequency of 20 cyc, on the "OHMS" range; 0 to 50 meg resistance measuring ranges; ±2% on "OHMS" and "OHMSx100" ranges, ±5% on "MEGOHMS" range, ±5% on "OPENS" or capacitance range; dc (batteries) 90 v, 4.5 v, 1.5 v; .009, .0, .150 amp; 10-7/8" lg x 7-3/8" wd x 6-3/4" d; Sig C Capacitance-Resistance Bridge ZM-7/TSM; spec No. MIL-T-2487.	Measures capacitance or resistance by comparison with standard capacitor or resistors.	3F-2007-2.1
(C1, C2, C3, C4) Fig. 26	CAPACITOR, fixed: mica dielectric; 5100 uuf ±5% tolerance 500 vdcw; 2 wire lead type term., located one on ea end; spec JAN-C-5; JAN type CM35D512J.	C1--Part of frequency-determining, feed-back network in oscillator (V1). C2, C3, C4--Oscillator (VI) plate tuning.	3K3551242
(C6) Fig. 26	CAPACITOR, fixed: mica dielectric; 10,000 uuf ±10%; 300 vdcw; 2 wire lead type term., located one on ea end; spec JAN-C-5; JAN type CM35B103K.	Coupling capacitor between oscillator (V1) output and amplifier (V2) control grid.	3K4010321

(C10) Figs. 26, 27	CAPACITOR, fixed: mica dielectric; 500,000 uuf ±1%; 500 vdc - 0 to +30 parts per million per deg C temp coefficient; 2 solder lug type term. 3/8" h, located on top, spaced 1-1/4" c to c.	Standard comparison capacitor for OPENS measurements.	3DA500-478
(C5) Fig. 27	CAPACITOR, fixed: paper dielectric; 100,000 uuf +20%, -10%; 600 vdcw; 2 solder lug type term. 3/4" h, located on side, spaced 1" c to c; spec JAN-C-25; JAN type CP53B1DF104V.	Oscillator (V1) screen-grid decoupling capacitor.	3DA100-634
(C7) Figs. 26, 27	CAPACITOR, fixed: paper dielectric; 4.0 uf +20%, -10%; 600 vdcw; 2 stud type term. 1" h, located on bottom, spaced 1-1/8" c to c; ceramic pillars; JAN type CP70E1EF405V.	D-c blocking capacitor between amplifier (V2) and transformer (T1).	3DB4-279
(C8) Fig. 27	CAPACITOR, fixed: paper dielectric; 2.0 uf ±10%; 600 vdcw; 2 solder lug type term. 3/4" h, located on side, spaced 1-1/16" c to c, painted w/ins lacquer; JAN type CP53B1FF205K.	Harmonic bypass in phase shifter.	3DB2-143
(C9) Fig. 27	CAPACITOR, fixed: paper dielectric; 1.0 uf ±10%; 400 vdcw; 2 solder lug type term. 3/4" h, located on side, spaced 1-1/16" c to c; painted w/ins lacquer; JAN type CP53B1FE105K.	Transformer tuning capacitor.	3DB1-154

Identification Table of Parts (contd)

Ref symbol or fig. No.	Name of part and description	Function of part	Signal Corps stock No.
Fig. 1	CLIP: electrical; alligator style; steel, nickel coated; 1 screw type term. 7/8" jaw opening when fully spread; Sig C Test clip TL-137; dwg #SC-B-6592.	Make connection to line to be tested (lineman's clip).	3Z1137
(P1) Fig. 23	CONNECTOR, plug: 7 cont male, round, polarized; plug-electrical connector type AN3106-16s-1P; spec AN-W-C-591.	Makes connections between control panel, batteries, and chassis components.	2Z7117.4
(P2, P3)	CONNECTOR, plug: 3 cont male, round, polarized.	Makes connections to 45-volt battery.	2Z7113.34
(J1) Figs. 26, 27	CONNECTOR, receptacle: 7 cont female, round, polarized; 1-3/8" lg x 1-9/32" wd x 1-9/32" d o/a; receptacle-electrical connector type AN3102-16s-1s; spec AN-W-C-591.	Makes connections between chassis components, control panel, and batteries.	2Z8677.49
(M1) Figs. 3, 24	GALVANOMETER: panel mtd, circuit application; zero ctr, 15 divisions on ea side, graduated in 30 scale divisions marked -10, -5, 0, +5, +10; fan shape, plastic case; 15 ua required for full scale deflection; strip suspension for coil, external magnet, 250 ohms coil resistance; Sig C galvanometer for general purpose use.	Indicates capacitance-resistance bridge balance.	3F2821-1

Fig. 3	KNOB: bar shaped; blk phenolic plastic; brass insert; Sig C knob dwg #SC-D-11513E.	Indicates position of selector switch (S7).	2Z5824.35
(W) Fig. 1	LEAD SET, test: blk wire Sig type #WS-16/U; one test prod, one test clip; Sig C connecting leads dwg #SC-C-11516, Group II.	Makes connections between equipment and line to be tested.	3E7998-60
Fig. 1	LEAD SET, test: red wire WS-17/U; one test prod, one test clip; Sig C connecting leads; quantity in use, 3.	Makes connections between equipment and line to be tested.	3E7215.1
Fig. 3	POST, binding: brass silver pl cap and base; Sig C dwg #SC-D-530Q, type TM-149.	Accommodates test prods of test leads.	3Z249
Fig. 1	PROD, test: replaceable phone tip per Sig C dwg #SC-B-6880; plastic handle, type RTP-EM-1 per spec JAN-P-15, red smooth finish, 1" lg; wire attached to tip by knurled nut Sig C dwg #SC-B-6881; Sig C dwg #SC-C-6879, Group II.	Connection to test set terminals.	3F3705-12.2
(CR1) Fig. 26	RECTIFIER, metallic: copper-oxide; designed for single-ph full wave circuit, MBCA Ref Dwg Group 23; rectangular shape; 1-5/8" lg x 3/4" wd x 1-7/8" h o/a; two 1/8" dia mtg ears on 1-3/8" mtg/c; 6 solder lug type term, located on top.	Rectifier circuit.	3H4956-63

Identification Table of Parts (contd)

Ref symbol or fig. No.	Name of part and description	Function of part	Signal Corps stock No.
(R13, R15) Fig. 27	RESISTOR, fixed: comp; 390 ohms ±10%; 1/2 w; insulated; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF391K.	Part of center-tap network across the input to modulator (CR1).	3RC20BF391K
(R9) Fig. 26	RESISTOR, fixed: comp; 1 meg ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF105J.	Grid-leak resistor for control grid of amplifier (V2).	3RC20BF105J.
(R8) Fig. 26	RESISTOR, fixed: comp; 3.9 meg ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF395J.	Coupling resistor between output of oscillator (V1) and control grid of amplifier (V2).	3RC20BF395J
(R6) Fig. 26	RESISTOR, fixed: comp; 5.1 meg ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF515J.	Voltage-dropping resistor for screen of oscillator (V1).	3RC20BF515J
(R2, R7) Fig. 26	RESISTOR, fixed: comp; 510,000 ohms ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF514J.	R2--Part of frequency-determining, feedback network in oscillator (V1). R7--Plate loading resistor of oscillator (V1).	3RC20BF514J

(R3, R4, R5) Fig. 26	RESISTOR, fixed: comp; 1.3 meg ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF135J.	Part of frequency-determining, feedback network in oscillator (V1).	3RC20BF135J
(R10) Fig. 26	RESISTOR, fixed: comp; 3000 ohms ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF302J.	Plate loading resistor for amplifier (V2).	3RC20BF302J
(R11) Fig. 26	RESISTOR; fixed: comp; 7500 ohms ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF752J.	Harmonic attenuator resistor in phase-shifter.	3RC20BF752J
(R16, R17) Fig. 26	RESISTOR, fixed: comp; 510 ohms ±5%; 1/2 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC21BF511J.	Part of center-tap network across output of modulator (CR1).	3RC20BF511J
(R18) Fig. 26	RESISTOR, fixed: comp; 20,000 ohms ±5%; 1 w; ins; resistant to humidity and salt-water-immersion cycling; spec JAN-R-11, JAN type RC31BF203J.	Current-limiting resistor for 45-volt batteries.	3RC30BF203J
(R19) Fig. 27	RESISTOR, fixed: WW; non-inductive wdg; 1 meg ±1%; 1 w; 85°C max continuous operating temp; precision wnd, 400 v max applied voltage.	Standard for MEGOHMS scale.	3Z1C6801-69

Identification Table of Parts (contd)

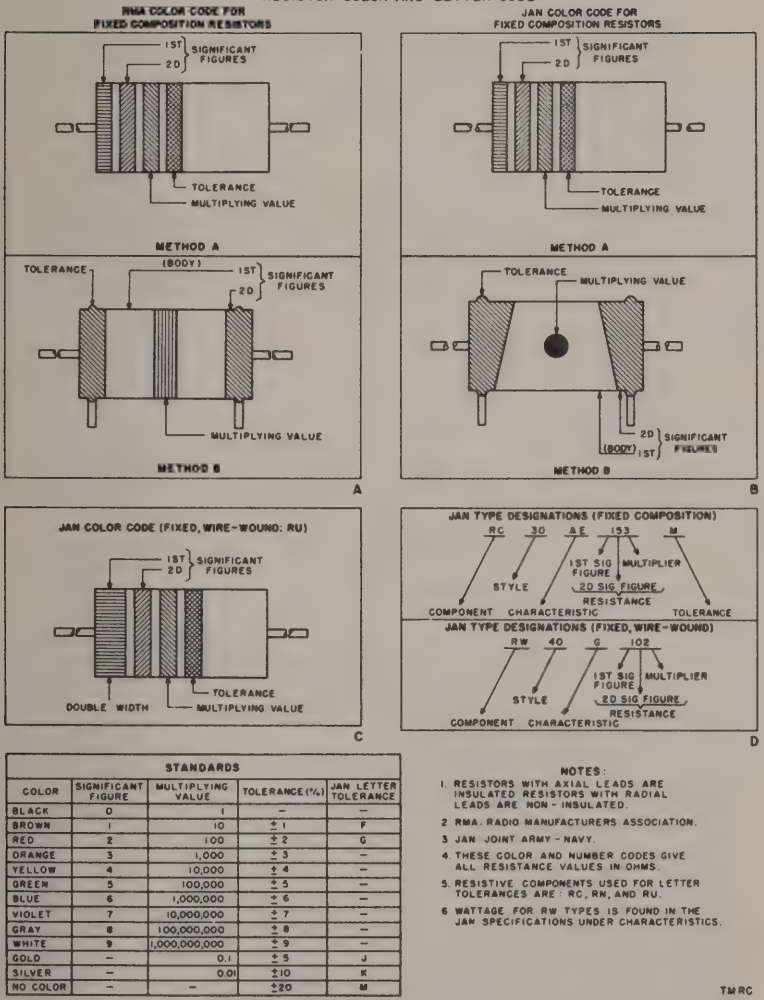
Ref symbol or fig. No.	Name of part and description	Function of part	Signal Corps stock No.
(R20) Fig. 26	RESISTOR, fixed: WW; non-inductive wdg; 10,000 ohms ±.1%; 1/4 w; 85°C max continuous operating temp.	Resistance standard for OHMS X100 scale.	3Z6610-119
(R21) Fig. 26	RESISTOR, fixed: WW; non-inductive wdg; 100 ohms ±.1%; 1/4 w; 85°C max continuous operating temp.	Resistance standard for OHMS scale.	3Z6010-86
(R1) Figs. 26, 27	RESISTOR, variable: 1 sect., 500,000 ohms ±20%; 2 w; spec JAN-R-19.	Oscillator tuning.	2Z7272-31
(R14) Fig. 27	RESISTOR, variable: WW; 1 sect., 200 ohms ±10%; 4 w; spec JAN-R-19, JAN type RA30A1SD201AK.	Part of center-tapping network across transformer (T1) output.	3RA4217
(R12) Figs. 26, 27	RESISTOR, variable: WW; 1 sect., 10,000 ohms ±10%; 2 w; spec JAN-R-19, JAN type RA20A1SD103AK.	Phase-shift control.	3RA7548
(R22) Fig. 24	RESISTOR, variable: WW; stationary-brush rotating wdg type; 1 sect., 550 ohms ±10%; 2 w; includes calibrated dial.	Forms two adjustable legs of capacitance-resistance bridge.	3-Z7255
Fig. 3	SCREW, thumb: steel, cold finish; cone point; Sig C dwg #SC-D-11515E4.	Secures battery cover to case.	6L17108-21P

(X1) Figs. 22, 26	SOCKET, electron tube: oval shape; spec JAN-S-28A.	Mounts vacuum tube (V1) (one mounts spare tube).	2Z8678.327
(X2) Figs. 22, 26	SOCKET, electron tube: round shape; spec JAN-S-28A.	Mounts vacuum tube (V2) (one mounts spare tube).	2Z8678.60
(S2, S3) Figs. 3, 23	SWITCH; lever: pile-up; 3 lever positions, locking; 1st position--4A4D, 2d position--2D4A2D, 3rd position--4A4D; 12 solder lug type term.; "D166110AF" stamped in body.	Changes connections to external circuits.	3Z9580-11.55
(S4) Figs. 3, 24	SWITCH, push: 2 units 2C, MBCA Ref Dwg Group 4; momentary action, 2 cont normally closed; 2 cont normally open; 6 solder lug type term., located axially at one end; "D163173A" stamped in body.	MEGOHMS push switch makes all bridge changes required for high-resistance measurements.	4C5105.76A.1
(S5, S6)			
(S1, Figs. 3, 24	SWITCH, push: 2 units, 1C and 1CA, MBCA Ref Dwg Group 4; momentary action, normally open; 8 solder lug type term., located axially at one end; "D163164A" stamped in body.	S1--OPENS push switch makes all bridge changes required for capacitance measurements. S5--Makes all bridge changes for resistance measurements on "OHMS X100" range. S6--Makes all bridge changes for resistance measurements on OHMS range.	3Z9824-34.15

Identification Table of Parts (contd)

Ref symbol or fig. No.	Name of part and description	Function of part	Signal Corps stock No.
(S7) Figs. 3, 24	SWITCH, rotary: 2 sect., 12 positions, max number of switching positions possible.	Selects circuits connected at input to test set and connects them to the appropriate arm of the bridge circuit.	3Z9825.55.44
(T1) Figs. 26, 27	TRANSFORMER, AF: plate coupling type; pri, 20,000 ohms, secd, 500 ohms, center tapped pri, 10,000 ohms; 6.32 to 1 ratio of turns, pri to secd; ±5 db from 100 to 10,000 cycles freq response, not tuned; spec MIL-T-27.	Impedance transformation.	2Z9632.382
(V1) Fig. 27	TUBE, electron: pentode; glass envelope, Radio Manufacturers Association; JAN 1LN5; JAN spec 1A.	Oscillator.	2J1LN5
(V2) Fig. 27	TUBE, electron: beam power tetrode; glass envelope, Radio Manufacturers Association; JAN 3Q5GT; JAN spec 1A.	Amplifier.	2J3Q5GT
(CR2) Fig. 24	VARISTOR: silicon-carbide type, 57 ohms resistance ±20% at 70°F w/applied voltage of 0.4 v dc for use up to 100 kc; "D-163298(4-51)" stamped on body; used as a current limiter.	Protects galvanometer (M1) against excessive voltage.	3H4956-62

RESISTOR COLOR AND LETTER CODE



STANDARDS

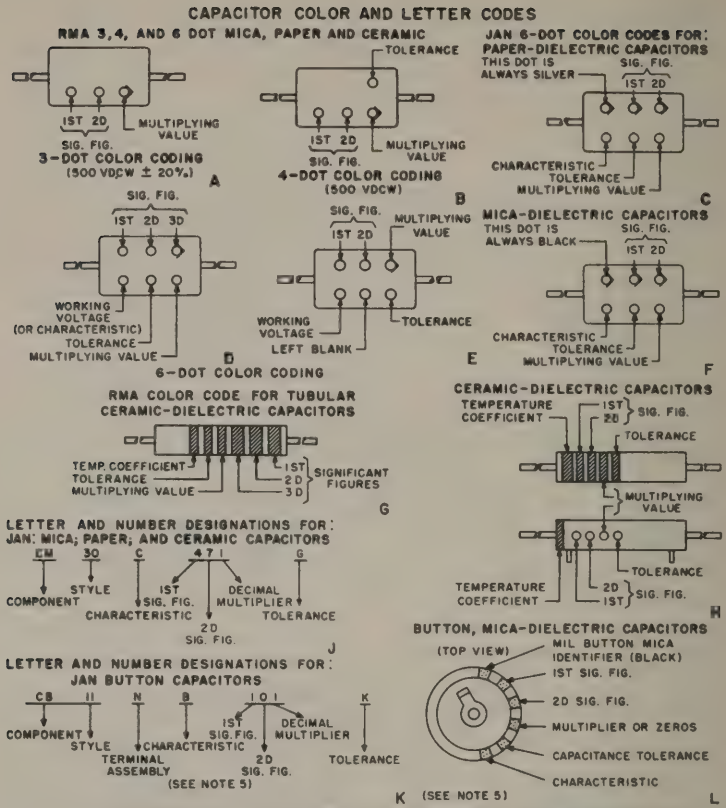
COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE	TOLERANCE (%)	JAN LETTER TOLERANCE
BLACK	0	1	–	–
BROWN	1	10	± 1	F
RED	2	100	± 2	G
ORANGE	3	1,000	± 3	–
YELLOW	4	10,000	± 4	–
GREEN	5	100,000	± 5	–
BLUE	6	1,000,000	± 6	–
VIOLET	7	10,000,000	± 7	–
GRAY	8	100,000,000	± 8	–
WHITE	9	1,000,000,000	± 9	–
GOLD	–	0.1	± 5	J
SILVER	–	0.01	± 10	K
NO COLOR	–	–	± 20	M

NOTES:

1. RESISTORS WITH AXIAL LEADS ARE INSULATED RESISTORS WITH RADIAL LEADS ARE NON-INSULATED.
2. RMA. RADIO MANUFACTURERS ASSOCIATION.
3. JAN JOINT ARMY-NAVY.
4. THESE COLOR AND NUMBER CODES GIVE ALL RESISTANCE VALUES IN OHMS.
5. RESISTIVE COMPONENTS USED FOR LETTER TOLERANCES ARE: RC, RN, AND RU.
6. WATTAGE FOR RW TYPES IS FOUND IN THE JAN SPECIFICATIONS UNDER CHARACTERISTICS.

TMRC

Figure 28. Resistor color and letter code.



- STANDARDS -					JAN MICA-CM		JAN PAPER-CP		JAN CERAMIC-CC					
									CAP. TOL. FOR MORE THAN 10 UUF			CAP. TOL. FOR 10 UUF OR LESS		
COLOR	SIG. FIG.	DECIMAL MULTIPLIER	% TOL.	VDCW	LETTER TOL.	CHARACTERISTIC	LETTER TOL.	CHARACTERISTIC	DEC. MULT.	%	LETTER DESIGNATION	UUF	LETTER DESIGNATION	CHARACTERISTIC
BLACK	0	1	±20	500	M	A	M	A	1	±20	M	±2.0	G	C
BROWN	1	10	± 1	100	-	B	-	E	10	± 1	F	-	-	H
RED	2	100	± 2	200	G	C	-	H	100	± 2	G	-	-	L
ORANGE	3	1,000	± 3	300	-	D	N	J	1,000	-	-	-	-	P
YELLOW	4	10,000	± 4	400	-	E	-	P	-	-	-	-	-	R
GREEN	5	100,000	± 5	500	-	F	-	R	-	± 5	J	±0.5	D	S
BLUE	6	1,000,000	± 6	600	-	G	-	S	-	-	-	-	-	T
VIOLET	7	10,000,000	± 7	700	-	-	-	T	-	-	-	-	-	U
GRAY	8	100,000,000	± 8	800	-	-	-	-	0.01	-	-	±0.25	C	B
WHITE	9	1,000,000,000	± 9	900	-	-	-	-	0.1	± 10	K	±1.0	F	SL
GOLD	-	0.1	± 5	1,000	J	-	-	-	-	-	-	-	-	A
SILVER	-	0.01	±10	2,000	K	-	K	-	-	-	-	-	-	-
NO COLOR	-	-	±20	500	-	-	-	-	-	-	-	-	-	-

* THE TOLERANCE OF THIS CAPACITOR IS ±30%, NOT ±3%

NOTES

JAN: JOINT ARMY-NAVY
RMA; RADIO MANUFACTURERS ASSOCIATION

1. THESE COLOR AND LETTER CODES GIVE CAPACITANCES IN MICROMICROFARADS
2. THIS TABLE IS ADAPTED FOR JAN AND RMA COLOR AND JAN LETTER TYPE DESIGNATIONS
3. CERAMIC AND MICA CAPACITORS, BOTH JAN AND RMA, ARE GENERALLY 500 VDCW
4. BUTTON CAPACITORS ARE GENERALLY 300 VDCW
5. READ BUTTON CAPACITOR TOLERANCE UNDER CERAMICS OF MORE THAN 10 UUF
6. CHARACTERISTICS ARE AVAILABLE IN JAN CAPACITOR SPECIFICATION MANUALS
7. THE COMPONENTS USED ABOVE FOR JAN LETTER TYPE DESIGNATIONS ARE:
   CP MICA BUTTON: CC CERAMIC; CM MICA MOULDED; CP PAPER MOULDED

TM CC

Figure 29. Capacitor color and letter code.

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I. FOR ALL MEASUREMENTS:

1. UNCLAMP GALVANOMETER BY SLIDING CLAMP FORWARD.
2. IF NECESSARY, ADJUST GALVANOMETER NEEDLE TO ZERO BY LOOSENING SET SCREW AND TURNING GALVANOMETER KNOB. THEN, TIGHTEN SET SCREW.
3. ALWAYS CLAMP GALVANOMETER BY SLIDING CLAMP IN DIRECTION OF ARROW WHENEVER TEST SET IS NOT IN USE.

II. TO DETERMINE KIND OF FAULT:

A. ONLY ONE FAULTY PAIR.

1. OPEN FAULTY PAIR AT BOTH ENDS OF LINE. DISCONNECT ALL EQUIPMENT.
2. CONNECT FAULTY PAIR TO LINE BINDING POSTS.
3. CONNECT A GROUND (EARTH) TO BINDING POST "G".
4. THROW CAM KEY TO "TEST"
5. MEASURE INSULATION RESISTANCE:
   a. WITH SELECTOR AT "T-R" (LOW READING INDICATES SHORT).
   b. WITH SELECTOR AT "T-G" (LOW READING INDICATES GROUND).
   c. WITH SELECTOR AT "R-G" (LOW READING INDICATES GROUND).
6. SHORT FAULTY PAIR AT DISTANT END.
7. MEASURE CONDUCTOR RESISTANCE:
   a. WITH SELECTOR AT "T-R" (VERY HIGH RESISTANCE INDICATES OPEN).

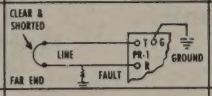
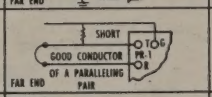
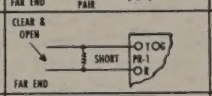
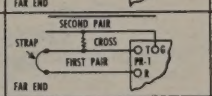
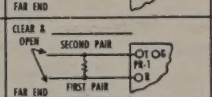
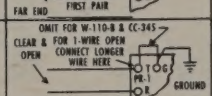
B. MORE THAN ONE FAULTY PAIR (MULTI-CONDUCTOR CABLE).

8. FOLLOW PROCEDURE 1-7 ABOVE FOR ALL FAULTY PAIRS.
9. CONNECT ONE FAULTY PAIR TO BINDING POSTS "PR-1".
10. REMOVE THE GROUND CONNECTION FROM BINDING POST "G" AND CONNECT IN ITS PLACE BOTH WIRES OF ANOTHER FAULTY PAIR.
11. MEASURE INSULATION RESISTANCE:
    a. WITH SELECTOR AT "T-G" (LOW READING INDICATES CROSSES).
    b. WITH SELECTOR AT "R-G" (LOW READING INDICATES CROSSES).

III. TO MAKE ABOVE MEASUREMENTS PROCEED AS FOLLOWS:

TO MEASURE	SET SELECTOR AT:	WAVE FAR END	DEPRESS KEY:	TURN KNOB UNTIL GALVO. READS ZERO & READ SCALE:	READ IN:	NOTES
INSULATION RESISTANCE	T-R, T-G, or R-G	CLEAR AND OPEN	MEGOHMS	D	MEGOHMS	1 MEGHOM = 1,000,000 OHMS. USE MEGOHMS KEY FOR VALUES ABOVE 500,000 OHMS; USE OHMS × 100 KEY FOR VALUES BELOW 500,000 OHMS.
			OHMS x 100	C	OHMS	
CONDUCTOR RESISTANCE	T-R	CLEAR AND SHORTED	OHMS	C	OHMS	VALUES OF RESISTANCE PER MILE FOR DIFFERENT TYPES OF WIRE ARE GIVEN IN INSTRUCTION BOOK.
			OHMS x 100	C TIMES 100	OHMS	
CAPACITANCE	T-R	CLEAR AND OPEN	OPENS	A	DIVISIONS	CONVERT DIVISIONS INTO UF CAPACITANCE BY REFERENCE TO CAPACITANCE CALIBRATION CURVE.

IV. TO LOCATE THE FAULT PROCEED AS FOLLOWS:

TO LOCATE:	CONNECTIONS	SET SELECTOR AT:	DEPRESS KEY MARKED	TURN KNOB UNTIL GALVO. READS ZERO & READ SCALE:	READ IN:	NOTES
GROUNDS		GNDS	OHMS	B	PER CENT	PERCENT × LENGTH OF LINE = DISTANCE FROM TESTING END TO FAULT. CONDUCTORS OF A PAIR BEING MEASURED ARE ASSUMED TO HAVE EQUAL RESISTANCE.
SHORTS (GOOD WIRE AVAILABLE)		GNDS	OHMS	B	PER CENT	PERCENT × LENGTH OF LINE = DISTANCE FROM TESTING END TO FAULT. GOOD CONDUCTOR OF PARALLELING PAIR MUST HAVE SAME RESISTANCE AS FAULTY CONDUCTOR.
SHORTS (NO GOOD WIRE AVAILABLE)		T-R	OHMS	C	OHMS	DIVIDE OHMS READING OBTAINED BY LOOP RESISTANCE PER MILE TO GET MILES DISTANCE TO FAULT. THIS METHOD IS ONLY APPROXIMATE.
CROSSES		GNDS	OHMS	B	PER CENT	PERCENT × LENGTH OF LINE = DISTANCE FROM TESTING END TO FAULT. CONDUCTORS OF A PAIR BEING MEASURED ARE ASSUMED TO HAVE EQUAL RESISTANCE.
CROSSES (ALTERNATIVE METHOD)		T-R	OHMS	C	OHMS	DIVIDE OHMS READING OBTAINED BY LOOP RESISTANCE PER MILE TO GET MILES DISTANCE TO FAULT. THIS METHOD IS ONLY APPROXIMATE.
OPENS		T-R	OPENS	A	DIVISIONS	CONVERT DIVISIONS READING INTO MILES DISTANCE TO FAULT BY REFERENCE TO PROPER CURVE SHEET.

SC-D-11517-A

TM 2057A-30

Figure 30, Instructions, Test Set TS-27B/TSM.

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